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A case study of an elementary science teacher's efforts to transform students' scientific communication from "informal science talk" to "formal science talk"

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A case study of an elementary science teacher's efforts to transform students' scientific communication from "informal science talk" to "formal science talk"

by

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Dedication

This work is dedicated to Leon Adrian Lester (1968-2003) for without the pleasure of knowing him I would have never become the person I am today. Leon always said, “You can do it La Vergne, I believe in you.” He said those words whether I was trying to climb a cocoanut tree or crying about not doing well on a physics exam.

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A case study of an elementary science teacher's efforts to transform students' scientific communication from "informal science talk" to "formal science talk"

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This investigation examines how Ms. Jones scaffolds students' science language development. The study closely investigates the instructional strategies she used to help her students move from "informal Science talk" to "formal Science talk," and looks at the strategies she implemented under the scope of the anticipated themes of verbal cues, non-verbal cues, and praise. "Informal science talk" is defined in this study as a limited domain of discourse with little or no science vocabulary, while "formal science talk" is defined as an extended discourse that included the appropriate uses of science-specific vocabulary.

In Ms. Jones' classroom the goal is to teach for understanding and lifelong learning, in accordance with the book *How People Learn* (National Research Council 2000), which contains implications for the teaching of Science. According to the standards of that book, Ms. Jones has the required subject knowledge, and an understanding of how students learn and the short- and long-term outcomes of such learning. She has created a classroom environment that fosters student thinking through participation in high-quality lessons and laboratory experiments. Through an iterative

process of questioning and answering, students are given the opportunity to think about what they are learning and to also self- assess and be able to understand what they do not know.

The research method used was a case study, that allowed the researcher to study, interpret and present an in-depth investigation of one teacher and how she scaffolded her students' language of school Science (LSS) development with technical vocabulary as an integral part of that process. The method of analysis was developed from a sociocultural perspective of learning. Classroom observations were conducted, and recorded via fieldnotes and videotaping of lessons for five weeks during the Spring of 2005 and four weeks during the Spring of 2006. The themes that emerged showed that the teacher's instructional designs were embedded in the Inquiry Model (Data Set I—Spring 2005) and the Science Process Skills Model (Data Set II—Spring 2006).

The findings of the study reveal the characteristics of a superior type of learning environment organized around the instructional designs that Ms. Jones used. Her technique promoted the development of rich science language integrated with the vocabulary of the domain. Ms. Jones' medium of instruction was "talk." She overtly used verbal cues to promote her students science language development, which was the language of school science and reflected the different domains of the subject at the elementary grades (the Nature of Science, Life, Earth, and Physical Sciences). This study shows that a knowledgeable teacher not only knows the subject matter; she also knows how to give the right feedback, what demonstrations or analogies to use, and how to engage students in scientific investigations while providing appropriate support (scaffolding).

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Chapter I: Introduction

> [All] children come to school well able to think and reason about the world in situations that make human sense to them. What they have to learn to do in school is to think and reason in "disembedded contexts"… to use symbol systems and deal with representations of the world. (Donaldson, 1978, pp. 88-89 in Beck & McKeown, 2001, p.10).

INTRODUCTION

In 2008, fifty-four (54?) years since the U.S. Supreme Court's historic *Brown v. Board of Education* decision, the racial gap in student achievement is as pronounced as ever. In those fifty-four years, efforts at improving minority education have received federal funding buttressed by legislation such as Title I of the Elementary and Secondary Education Act, the compensatory education program, Head Start, the Bilingual Education Act, and the creation of guidance and counseling programs in schools. Funding has been provided explicitly for additional educational resources for children from low-income homes, premised on the idea that they require more educational services than children from affluent homes. The idea was to obligate the educational system to ensure "high standards and accountability for the learning of all children, regardless of their background or ability" (National Education Association).

Since the 1954 court ruling on desegregation, these developments regarding education have underscored the need to ensure that access to a quality education is equitable among all residents of the United States. But if we were to examine each of these developments carefully, we would find ample evidence that a quality education is still unavailable to many Black, Latino, and poor students. Some might go so far as to say that the civil rights issue of our time is the "achievement gap." Most of the attempts to close the achievement gap have subscribed to the remedies of compensatory programs, high stakes testing, and standards, such as the National Science Education Standards (NSES). These reform efforts have consistently "ignored the sociocultural, political, and economic contexts of the individual students they are impacting," as Gale Seiler points out. To further illuminate the failure of already marginalized students, the No Child Left Behind Educational Act (NCLB) was implemented in Texas in 2002.

NCLB (2001), an addendum to the Elementary and Secondary Education Act (ESEA, 1965), increases the number of annual standardized tests given to students in Science at the fifth, eighth, and eleventh grades. Additionally, NCLB has called for the disaggregation of all standardized testing data into subgroups (Asian, Caucasian/White, African American/Black, Hispanic/Spanish Speaking, and Native American) and has specifically targeted students from low-income homes. These programs have provided us with more than enough data pointing to the further need for improvement in education for minority groups in reading, mathematics, writing, and Science. The investigation described in these chapters examines Science Education at the elementary grades. Most researchers agree that the quality of science instruction is connected to the uniqueness and diversity of the learners (Brown, 2005; Lee, 1991; Lemke, 1990, 1996, 2001; Seiler, 2002).

Some students of color — African-American students in particular — express high interest in Science, enjoy learning, and feel confident about doing it at the elementary-school level. But these students consistently receive lower grades on standardized assessments of Science achievement (Hanson & Johnson, 2000; Hill & Pettus, 1990; Kahle, et al. 1994). In general, research has revealed that Black and Latino students lag behind white students in nearly all measures of academic achievement in the Sciences — from course taking to standardized testing to postsecondary degree attainment (NSF 1996; Oakes, Gamoran, & Page, 1992; Oakes and Wells, 1998; U.S. Census Bureau, 2001). Since advanced course work in Science is a prerequisite for entrance into Science careers, it is reasonable to assume that this documented lower participation in Science classes results in lower participation in Science careers by minority groups. Low representation in Science careers by minorities is well documented (U.S. Census Bureau, 2001).

I refer to this low participation as the "wound" — an intentional word choice to illuminate that despite good intentions, from court decisions to federal funding, there is still a paucity of minority students in the "hard science" classes in high school. The word "wound" is appropriate even now, fifty-four years after *Brown v. Board of Education,* because inequitable schooling, characterized specifically by course selection, taking, and proficiency in assessment in high school and beyond, still exists. Available quantitative data, from standardized examinations, from the National Assessment of Education Progress (NAEP, 1969 - Present), and from the American Institute of Physics (AIP, 2004-2007) have highlighted deficiencies in minority participation in courses in mathematics, reading, writing, Science and physics. According to the AIP, the percentages of high school students who took Physics from 1990 to 2001 increased as follows: Asian (from 34 to 47%), white (24 to 33%), Black (10 to 22%), and Hispanic (10 to 21%). The increase in participation across racial groups resulted from an enhanced spectrum of course offerings in physics from conceptual to advanced placement and honors classes. Despite this reported increase by African-American and Latino students, these populations are still lagging behind their Anglo and Asian-American counterparts. This difference is more prevalent at the high school level because students, with their guidance counselors, are allowed to make choices about what courses they will take. In contrast, elementary school students have no choice of which courses they take. Many students tend to make career choices between the late elementary school years (grades 4–6) and early junior high school years, which makes this a critical window of opportunity (Campbell, 1991; Kahle, et al. 1994).

Purpose

The purpose of the study is to closely examine the instructional strategies used by a teacher to determine how she builds (or scaffolds) her students' language development. I argue that appropriate instructional strategies at the elementary level are critical to building student's confidence in Science so that they feel empowered to choose Science courses once they are in high school. This empowerment is developed through "talk" that teachers and students are engaged in at the elementary level. The focus of the study is to understand how one teacher, Ms. Jones, scaffolds the language of school Science (LSS) development with technical vocabulary as an integral part of that process. She helps students transition from "informal science talk" to "formal science talk."

SCIENCE AS A CONDUIT TO LEARNING AN ACADEMIC LANGUAGE

The philosophical and theoretical framework of this study is situated against the backdrop of research published by linguists Gee (2004), Lemke (2004), and Roth (2004) who have systematically examined the various languages of Science. What does it mean to be able to talk or write or read Science? Science requires an academic language that teachers must help students acquire. Teachers should be cognizant of and sensitive to the various languages (discourses) and cultural suppositions students bring to school (Gee, 2004). Instructional design choices must focus on learning that will serve students in the future; and key to these strategies is the mastery of the language of Science in order to participate in the culture and community of Science.

The Framework

As Jay Lemke writes, the language of Science "is a unique hybrid: It is a natural language as linguists define it … contextualized by visual representations of many sorts, and embedded in a language (or more properly, a semiotic) of meaningful, specialized actions afforded by the technological environments in which Science is done" (Lemke 2004, p. 33). For the purposes of this study, I have adapted Lemke's concept of the Language of Science (LOS) to form a concept more useful to understanding scientific learning in a school setting. Hence in this study I will refer to the Language of School Science (LSS) as the academic language students need to learn to move forward in scientific study. Additionally, the theoretical framework includes contributions from Delpit (1995), Ladson-Billings (1994), and Vygotsky (1978) because their work has provided further insights into the social aspects, culture and language relationships of teaching and learning. My aim is to use this foundation to build a structure supported by constructivism and cultural considerations, integrated with the deliberate need to learn the Language of School Science and its requisite vocabulary.

According to Vygotsky (1978), learning involves language, which is a social activity, and methods of instruction must consider the child's level of cognitive development. Table 1.1 provides descriptions of the terms that were germane to a study that employed the tenets of a sociocultural perspective of teaching and learning.

Table 1.1: Teaching and Learning from a Sociocultural Perspective

<table>
<tr><td>Terms and Descriptions</td><td rowspan="4">Students are treated as individuals at the planning stage only. But these students must work in collaborative and mediated (by the teacher) interactions once in the learning milieu[1].</td></tr>
<tr><td>Learning involves language: Language and learning are inextricably intertwined (Vygotsky). People talk to themselves as they are learning, but in a collaborative setting that chatter is expressed externally and becomes available for debate.</td></tr>
<tr><td>Learning is a social activity: Teachers, peers, family members and other people enable children to learn. A continuation from Dewey's formulation recognizes the social aspect of learning and uses conversations, interactions with others, and the application of knowledge as integral aspects of learning.</td></tr>
<tr><td>Methods of instruction: In planning topics and methods of instruction, educators must consider students' levels of cognitive development. Pre-operational kindergarteners require explanations based on concrete operational logic. Concrete-operational elementary school children learn more effectively if the information is presented through concrete, hands-on examples. Students at this age, 5 through 11 years old, encounter difficulties in understanding abstract ideas that do not tie in with their own experiences.</td></tr>
</table>

Adapted from Vygotsky, L. S. (1978). Mind in society. Cambridge, MA: Harvard University Press.

The terms in table 1.1 were selected to guide what I will take note of in this study. The intent is to address classroom interactions from a sociocultural perspective. The situative perspective (or sociocultural perspective) is the primary perspective with regard to language development, in that the constructs of language and interpersonal discourse shaped the environment within which learning occurs. As Lemke notes, "In the sociocultural view, what matters to learning and doing Science is primarily the socially learned cultural traditions of what types of discourses and representations are useful and how to use them, far more than whatever brain mechanisms may be active while we are doing so" (Lemke, 2001, p. 298). Sociocultural constructs provide a context for relevance by situating new concepts relative to known, established concepts.

According to the situative model, success is built upon an existing foundation, through an iterative process of student speaks→fellow students/teacher assess→fellow students/teacher speaks→student responds (speaks)→fellow students/teacher assess, etc. In this manner, students lead themselves to an understanding of the unknown by charting a path that inches toward the unknown from the comfort of that which was previously known.

[1] The term 'milieu' will be used in place of classroom and laboratory. Milieu is defined as one's social environment (Mac OS X) dictionary. The social environment in this study is the one coconstructed by Ms. Jones and students whether they were in the laboratory or the classroom.

The Theories

The selected learning theories that guided this study call for teaching practices that enable students to acquire, develop and use cognitive tools in authentic domain activities — the laboratory exercises that Ms. Jones planned, organized, and facilitated. She was extending an invitation to each child to venture into the culture of Science because as Bruner (1990) wrote, "It is culture, not biology, that shapes human life and the human mind" (p. 34). These theories present common-sense ideas, if the aim of instructing is to "stretch" learners' motivations for immediate and later endeavors. The theories are described in table 1.2, presented below.

A process of guiding the learner from what is presently known to what is to be known is *scaffolding*, a major aspect of social constructivism. As Vygotsky (1978) indicated, problem-solving skills fall into three categories: independent, instructional, and frustrational [See diagram 1.A. below]. The triangle represents the fact that each child requires a different amount of teacher intervention. The base of the triangle is widest and represents students at the frustrational level who require more intervention by the teacher.

Table 1. 2: Learning and Teaching: Constructivism in learning

<table>
<tr><th>Theory</th><th>Description</th></tr>
<tr><td colspan="2">Constructivist
Dewey: Emphasized the place of experience in education
Piaget: Substantiated through evidence-based results that children's minds were not empty, but actively processed the material with which they were presented, and postulated the mechanisms of accommodation and assimilation as key to this processing.
Vygotsky (1978): Social constructivist theory — "Zone of Proximal Development" (ZPD), which connotes that students will perform better on tasks when they work in tandem with a teacher or more experienced peer than when they work on their own. "The process of [interaction] with the adult enables them to refine their thinking or their performance to make it more effective. Hence, for [Vygotsky], the development of language and articulation of ideas (with fluent use of the technical vocabulary of the language) was central to learning and development."</td></tr>
<tr><td colspan="2">Social Development - Vygotsky (1978) states: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and then inside the child (intra-psychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals." (p. 57).
A mediated interaction between teacher and student(s) or a student and a peer (s) – ZPD.</td></tr>
</table>

Social Learning - ***Bandura (1977)*** states: "Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action." (p. 22).
A mediated interaction between teacher and students where the teacher models the *Process* Skills or utilizes the tenets of the *Enquiry Model* to aid students in the transition.

Adapted in part from: ATHERTON J S (2005) Learning and Teaching: Constructivism in learning [On-line] UK: Available: http://www.learningandteaching.info/learning/constructivism.htm Accessed: 7 May 2000

Teacher intervention through mediation---Scaffolding

Scaffolding

Independent ↓	Skills the student can perform independently ↓
Instructional ↓	Skills the student can perform with help ↓
Frustrational	Skills the student cannot perform

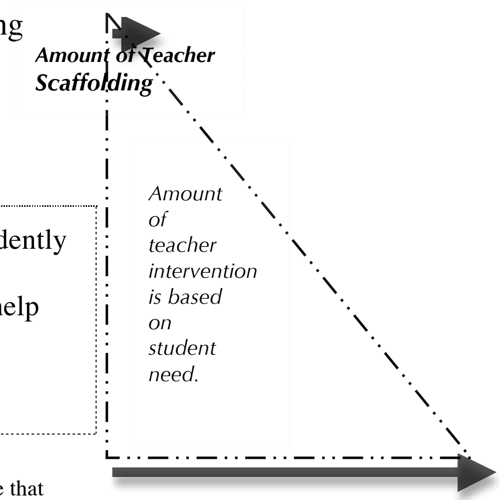


Figure 1.A. Teacher intervention through mediation---Scaffolding.
Adapted in part from reading education. The dashed lines indicate that the interactions are dynamic. The triangle represents the fact that each child requires a different amount of teacher intervention.

Scaffolding, a temporary support system, allows students to perform tasks that would normally be slightly beyond their ability without that assistance and guidance from the teacher. Appropriate mediation, on the part of the teacher or a more experienced peer, allows students to function at her/his individual developmental stage or beyond. Therefore, scaffolding is an important characteristic of constructivist learning and teaching.

Ms. Jones incorporated a variety of integrated techniques (from the other disciplines that are part of her academic and practical repertoire as an elementary school teacher) to accomplish the vocabulary-rich language and academic content objectives of the Science curriculum. At this level of schooling, Science is a compilation of the individualized subjects (such as Life, Earth, and Physical Sciences, Biology, Chemistry, and Physics) that students will take during secondary school grades.

Understanding the academic language of school Science is "the great enterprise of paying attention to the kinds of meanings that require us to go beyond natural language" (natural language as defined by linguists) (Lemke, 2004). Without encouragement to adopt the language of school Science (LSS), children of color lack the discursive tools needed to mentally manipulate and apply scientific concepts in circumstances other than those in which the concepts are initially taught. Without mastery of the LSS, young students of color may not be able to picture themselves as scientists. This alone does not preclude the possibility of those children eventually becoming scientists, but the absence of such a self-image may adversely affect the likelihood that these children will choose coursework leading to careers in Science.

Language is the primary form of communication through which the teacher can transmit scientific knowledge, specifically those abstract concepts that have been developed over time and are reified in language. Students' ability to communicate the specialized language of Science correctly reflects their grasp of those scientific concepts. Acquiring the vocabulary of Science is necessary for success, not only in the immediate situation or interaction that occurs in the classroom, but also for communication with the scientific community at large. "Formal Science talk" is the academic discourse of school Science. My view of language in the Science classroom, the phraseology and vocabulary of a domain, is supported by the idea of "saying it your way" as a starting point with the teacher in the role of the mediator in the transition from informal Science talk to formal Science talk (Delpit, 1994, Lemke, 1993, and Vygotsky, 1978). My definition of formal Science talk parallels Lemke's "talking Science," where Science is demarcated from other subjects by "observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and the language of [school] Science" (p. *ix*). Formal scientific language abounds in specialized vocabulary that should be taught and learned in the dialogue of the Science lesson or classroom. Acquisition of this language is necessary for comprehending text, passing an examination, listening to and following teacher instructions, and success at the secondary and post-secondary school levels.

Many students do not talk about Science with the same scientific language that teachers, scientists, and textbooks use. Culturally and linguistically diverse students have acquired ways of knowing and learning from home and community and tend to experience difficulty with "the rules and language of power" in school Science and other academic subjects (Banks, 1995; Delpit, 1998; C. D. Lee, 2001; and O. Lee, 2002). The language of power includes the skills and control over the specific written and spoken discourse that African-American children, in particular, must develop through explicit teaching in the ways of talking, writing, interacting, and valuing (Delpit 1986, 1988; Warren & Rosebery, 1993). The quote that introduced this chapter suggested that children come to school well prepared to learn, and that they possess meaning and fluency in language from their homes and communities. Through systematic actions on the part of the teacher, students will learn how to think and reason and how to communicate in what is defined as school Science. Researchers have suggested that some students are reluctant to ask questions in the classroom (Atwater, 1994, McKinley et al, 1992, and O. Lee, 2002). Therefore, teachers should listen to and analyze elementary students' talk about Science because this critical analysis will help them guide their students to translate "everyday talk" into "Science talk" (Harlow & Otero, 2004).

Another element of the discussion about minority education focuses on progressive pedagogies, which emphasize meaning over form, process over product, and contextualized learning over decontextualized learning. In doing so, some argue, these pedagogies may actually undercut minority children (Delpit, 1986, 1988)—specifically, African-American children. Additionally, the spoken and written discourse forms, which are used by teachers and in standardized examinations, are the discourse patterns that middle-class children learn at home and get to practice at school (Delpit, 1986, 1988; Gee, 2004; Warren & Rosebery, 1993). Delpit and others contend that Hispanic/Latino, Black/African American, Native American Indian, and linguistic/language-different children mainly learn and practice these discourse patterns at school--shepherded by their teachers.

AN OVERVIEW OF THE STUDY: A FOCUS ON INSTRUCTIONAL STRATEGIES

There is no one method to successfully teach all students. Therefore instructional approaches should be responsive to the diverse strengths, needs, backgrounds, interests and ways of learning that each student brings to school. In addition, instructional strategies should vary depending on the learning environment (e.g., whole class, small group, and one-on-one with a student). For these reasons it is important to understand how teachers successfully contextualize their teaching. How do these teachers explain their selection of strategies and how do they use their explanations to guide their decisions in subsequent lesson planning and strategy implementation?

Ms. Jones, the teacher upon whom this study is based, would be defined by the No Child Left Behind Act (NCLB, 2001) as a highly qualified teacher (HQT). She demonstrates subject-area competence in Earth Science, Physical Science, Life Science, and the Nature of Science, which makes her an ideal teacher at the elementary level. Furthermore, she explains her approach to teaching as understanding, respecting, and responding to her students' cultural backgrounds. Her teaching reflects what Paulo Freire once wrote: "dialogue involves respect." This type of pedagogy is what Gloria Ladson-Billings (1994) describes as "culturally relevant," which builds upon Vygotsky's (1978) explanation of learning as being fundamentally cultural. Beyond her duties as a teacher in the classroom, she also "models" for novice teachers and prepares and actively facilitates professional development workshops for inservice teachers. Thus, the community deems her highly qualified. In this research, a case-study methodology was employed and data collected and analyzed including audiotapes of teacher interviews, videotapes of classroom interactions, samples of classroom assignments, the school district's instructional planning guide (IPG) and nine-week examination, and the TAKS instructional booklet with sample test. My goal was to ferret out teaching strategies that lead to student success in Science at the elementary school level. For these reasons, I framed the research question around this teacher's daily life in the classroom:

> ***How does this teacher scaffold students' transition from "informal science talk" to "formal science talk"?***

In addition to recognizing the importance of teachers' training and skills in their students' academic success, recent findings in educational research emphasize the importance of knowing what each child brings to the classroom (Delpit, 1995; Ladson-Billings, 1994; NCLB, 2001). As ideas for reforming education mature, they set the path for teachers to challenge societal norms that "label" and place limitations on the abilities of an increasingly diverse student population.

New knowledge of how people learn, along with the growing applicability of Vygotsky's work, requires employing an instructional style that is consistent with culturally relevant pedagogy (CRP). Many researchers describe CRP as an effective means of meeting the academic and social needs of culturally diverse students. CRP emphasizes teaching to and through the strengths of all students while responding to, validating, and affirming differences (Ladson-Billings, 1994). Therefore, for the present study a theoretical framework which included sociocultural and constructivist paradigms was used to conduct the case study investigation and to analyze the data surrounding this teacher, Ms. Jones, as she taught, modeled, and provided professional development for other teachers.

Thus, the purpose of this research is to determine how Ms. Jones scaffolds students' language development. By closely examining the instructional strategies she uses to help her students move from "informal Science talk" to "formal Science talk," my study explores what factors she took into consideration when making those choices at various points of convergence between her scaffolding techniques and her students' use of technical vocabulary. For this study, "informal Science talk" will be defined as a limited domain of discourse with little or no Science vocabulary, while "formal Science talk" will be defined as an extended discourse that includes the appropriate use of Science vocabulary.

This study was designed as a case study that followed the five components outlined in Yin (1994): 1) the study question, 2) propositions, 3) unit of analysis, 4) logic of the data to the propositions, and 5) criteria for interpreting the findings. The proposition focused the study's goals and the unit of analysis defined the case. The unit of analysis was Ms. Jones and the method of analysis was developed from a sociocultural perspective of learning. A sociocultural perspective for data analysis and interpretation of the development of language and culture as observed in the laboratory and classroom defined this case.

I use the term “simultaneously available repertoires” (Rendon, et al, 2000) to explain myself as an instrument in the research design, implementation, data generation, gathering, and analysis. My experiences in the classroom, ranging from learner to teacher to observer/researcher, have provided me with a rich repository of skills from which to conduct a case study. Ms. Jones planned, organized and scaffolded laboratory activities — she communicated effectively, verbally and in writing, while interacting with students to facilitate learning.

The adopted theoretical frameworks were constructivist and social constructivist to explain the need for the appropriate use of technical vocabulary that was integrated into the instructional design that advocates for the accumulated growth, development and acquisition of the academic language of school Science. These perspectives are informed by the work of theorists who believe all learning is an active, interpersonal, and social process. Vygotsky's (1987) theoretical framework has been instrumental in illuminating the role of culture in learning; and Bruner's (1983) view of scaffolding provides an understanding of the support that children acquire from their teachers or more experienced peers as they learn the academic language of school Science, become meaning makers, and learn to effectively communicate.

Partisans of social constructivism argue that learning is influenced by the society and particular culture in which the students live (Bakhtin, 1986; Wertsch, 1993). Children learn language from interacting and communicating with the people around them. Ways of knowing, understanding, and communicating are learned unconsciously within the family, extended family, communities, and society; and the children then take these learning patterns to school. As Hutchins (1980) wrote, "Once learned, it becomes what one sees *with*, but seldom what one *sees*" (p. 12). Thus, cultural understanding and learning form the knowledge base that is drawn upon to make sense of and interpret life. However, culture is not static; it is fluid, ever changing, and adaptable (Bruner, 1986; Rosaldo, 1989).

Limitations of the Study

The case study method offers the opportunity to conduct an in-depth study of a purposeful sample. However, like any research method, there are limitations inherent in the approach. One limitation of this study in that only one teacher and her students in two classes were observed. That may limit our ability to generalize from the findings. There is also the potential for observer effects or biases to color interpretation. This is a major limitation of the present study, because the data was reviewed, transcribed, and interpreted only by the researcher. I attempted to minimize these challenges by preserving the original data in a form that can be re-analyzed or consulted again from a different viewpoint (Lemke, 1990). All of the data, including the videotaped classroom observations, are stored on DVDs that can easily be viewed by any interested parties; the audiotaped teacher interviews are also preserved. Also, I developed comprehensive appendices with verbatim transcriptions of interviews, subsets of classroom observations, and my field notes. Ideas about future research questions are presented in the concluding chapter. The data were analyzed from a sociocultural perspective, and culture was defined as “the attitudes and behavior characteristics of a particular social group,”[2] which is a lens that allows for interrelatedness of child, home, community, classroom, school, history, and any situation that allows for classroom socialization scaffolded by a more experienced other.

OVERVIEW OF THE FOLLOWING CHAPTERS

The study is presented in five chapters. Chapter II is a review of the literature, which includes research from reading, language arts and Science Education that focuses on vocabulary and appropriate usage. Chapter III explains the methods used in the study. Chapter IV presents the results. The discussion, conclusion, and suggestions for future research are presented in Chapter V. The names of the teachers (Ms. Jones and Ms. Drinks) used in this study are not pseudonyms because the teachers requested that their actual names be used.

[2] Mac OSX, Dashboard dictionary.

Chapter II: Review of Literature

> Science is not a list of facts and principles to learn by rote. It is a way of looking at the world and asking questions.
>
> —James Rutherford,
> Education Adviser to the American
> Association for the Advancement of Science

INTRODUCTION

It can be argued, based on research (Gee, 2004, Lemke 2004) that effective scientific communication skills should be developed through appropriate modeling and practice in using the technical terms encountered in textbooks, the teachers' language, examinations, the news media, and science journals or magazines. In contrast, accommodationist educators argue that as long as students can explain the concepts in a way that shows comprehension, it is not necessary for them to use the technical vocabulary. For the purposes of this study, "accommodationism" will be used in reference to the philosophy that students need not learn the technical, "official" language associated with scientific concepts, as long as some familiarity with those concepts is achieved. The word "accommodationist" may be used in reference to practitioners who espouse that philosophy as well. The term originated in debates surrounding the conflicting views of Booker T. Washington and W. E. B. Dubois; while Washington argued that black education should accommodate prevailing social realities, Dubois pushed for an educational strategy more focused on improvement and empowerment.

For example, a Vygotskian model emphasizes the importance of social interactions meditated by more experienced peers or teachers. Over the years researchers have found that the more interactions students have with mediators, such as a teacher or more experienced peer, the more effectively they learn. (Jensen, 1969) In other words, the presence and guidance of a knowledgeable mediator will yield better results than any amount of time a learner is given to explore and discover on his or her own.

The types of research that support these assertions focused on how to meet the academic and social needs of culturally diverse students. However, research that focuses on vocabulary acquisition, development and appropriate usage is derived mostly from studies in the disciplines of reading and language arts. Since similar research has not yet been undertaken in Science Education, this discussion is meant to bridge the gap between reading research and Science Education research.

Explaining "The Wound"

"The Wound" refers to a state of population-specific inequality that results from the coincidence of the following five conditions:

- Science-specific pedagogy does not adequately address methods and practices for enhancing science-related vocabulary acquisition; so
- Science teachers are not trained in methods and practices for enhancing Science-related vocabulary acquisition; and
- Students from vocabulary-poor backgrounds may lack the repertoire of core vocabulary needed for the transfer of non-technical vocabulary to the understanding of analogous technical terms; therefore
- Science teachers who lack training in vocabulary-building instructional strategies cannot address the needs of students who come to Science class needing explicit instruction in order to acquire Science-specific vocabulary; so
- Science teachers lower expectations for students from vocabulary-poor backgrounds, permitting such students to use simplistic mnemonics to represent or describe scientific concepts that would otherwise be signified by the use of specialized scientific terminology.

It would appear that any situation requiring the coincidence of these five conditions would be very rare. Unfortunately, the conditions above coincide in an increasing percentage of schools across the United States.

TEACHING AND LEARNING: A VYGOTSKIAN MODEL

For most individuals learning takes place during social interactions. According to Vygotsky (1978, in NRC, 2000, p. 184), "The emphasis on establishing communities of scientific practice builds on the fact that robust knowledge and understandings are socially constructed through talk, activity, and interaction around meaningful problems and tools." In such a situation the teacher scaffolds students' actions and/or interactions as they explore problems and pose questions (NRC, 2000).

A Vygotskian model, with the zone of proximal development as an integral component with social cognition, is a sound theoretical framework underlying various instructional strategies. It is also employed in this study, which focuses on one teacher. This teacher's instructional style incorporates elements of constructivism, which is a subset of the sociocultural theory of teaching and learning.

Constructivism

Constructivism is a theory of cognition based on research in psychology, philosophy and Biology, and it has been used in Mathematics and Science Education. According to Fosnot, this theory describes knowledge as "emergent, developmental, nonobjective, viable constructed explanations by humans engaged in meaning-making in cultural and social communities of discourse" (Fosnot et al., 2005, p. ix). The main characteristics of the constructivist approach to teaching and learning are, as Confey explains, "a focus on the learner, attention to prior and related knowledge, purposeful engagement with higher order cognitive thinking, the use of multiple forms of representation, and careful attention to explanation and argument" (Confey et al., 2000, p. 181). This translates into a Vygotskian model of teaching and learning that supports the notion that classroom activities/meaning-making occur within a social context that incorporates cultural artifacts, such as language and tools.

A constructivist classroom is a milieu that is student-centered. The teacher in the role of mediator prompts students by transitioning them from lower-order questions to higher-order questions, thereby advancing the students' thinking. The scaffolded question-and-response sequence is an iterative process in which the student is the center of the activity or discussion. His/her responses direct the mediator's questioning. The knowledge construction process transitions to higher phases of critical thinking based on the role and power structures developed during teacher-student and student-student interactions.

Scaffolding

Scaffolding is teacher intervention throughout the teaching/learning process. The teacher effectively and efficiently intervenes during class discussions, group work, and one-on-one interactions with students. According to the National Reading Panel (2000), the following characteristics were true of vocabulary instruction:

a. Vocabulary should be taught explicitly to enhance student understanding of abstract scientific concepts.

b. Vocabulary instruction is directly proportional to text comprehension.

c. Teaching dictionary definitions of terms may have limited value in alternative contexts.

d. Preteaching vocabulary enhances students' retention of concepts and their ability to transfer that understanding to other contexts.

e. Using easier words during direct instruction of new concepts is conducive to students' understanding of the concept. (The current study argues that such a scaffolding method is only to be used as a means to an end, and is not an end in itself. Once the student comprehends the concept via simplified vocabulary, the teacher must then finish the job and teach the associated vocabulary as well.)

f. Using both dictionary definitions and contextually-derived definitions to find meanings of words is most effective for comprehension.

g. Repeated use of the word within this and across other contexts solidifies the student's ownership of the new words.

h. Students from vocabulary-poor backgrounds, students from average and vocabulary-rich backgrounds all benefited from explicit instruction in vocabulary prior to reading expository texts.

Mediation (Tool and Social)

Mediation is teacher intervention that helps the student negotiate between the "everyday discourse" and the "Science discourse." Within this process of mediation learning and development occurs when students are presented with tasks that are in their zone of proximal development. Any activity that lies within that zone will foster social mediation because the student is placed in a situation in which she or he will need assistance that must be readily available so that the student will not feel frustrated or discouraged (Vygotsky, 1978).

Zone of Proximal Development (ZPD)

Figure 2.A (below) represents the Science milieu, within which use of the Science-specific vocabulary is facilitated among peer groups scaffolded by the teacher (Vygotsky, 1978).

Figure 2. A.ZPD

Science		***Reading***	***Level of Involvement***	***On-going Progress Monitoring***
Modeled task that is beyond the student's ability		*Frustrational Level*	Teacher-centered: The teacher is doing most of the work	Formative Assessment
Task that requires outside help or assistance	Z P D	***Instructional Level***	*Teacher-student interactions that provide a negotiation between the two that must lead to the student accepting/taking ownership of his/her learning.*	
Independent task (task the student has mastered). No new learning occurs		*Independent Level*	Student-centered: The student is doing most of the work.	Summative Assessment

The dashed lines indicate that the interactions are dynamic (movement can occur).

ZPD is the umbrella psychological theory that incorporates elements of scaffolding and mediation. It is viewed as a social system constructed by both teacher and student, in which the student helps to actively construct cultural meanings (Doolittle, 1997, p. 8). Vygotsky's (1978) ZPD reveals a pattern of development in which the student enters requiring support and leaves having achieved independent accomplishment. At the initial phase of the interaction, the teacher assumes most of the responsibility and continually adjusts the amount of scaffolding (or help) in response to the student's needs until the student reaches a level of actual development. (That is, the point at which the student begins to experience entirely new phenomena).

Science as a Language: Fluency in Science Talk situated in Lemke's Talking Science

Extended reviews of works that have looked at the issue of talk include AAAS (1993), Lemke (1990, 2001), O. Lee (1991), and Warren and Rosebery (1993). "Science Talk" without the "science registry" (the specialized vocabulary), is limited and powerless. This study dives into the specific details of the technical vocabulary. In all of their writings, Delpit (1995) and Lee (1991) discuss the "language of power" and what it means to partake in "Western Science." Some research (AAAS.1993; Delpit, 1995; Lemke, 2004; O. Lee, 1991; and Warren & Rosebery, 1993) encourages its readers to think about advocating to integrate the technical vocabulary into instructional design. The American Association for the Advancement of Science (AAAS, 1993) focuses on effective communication almost to the neglect of technical vocabulary, indicating that some scientific vocabulary is necessary in some situations (but not all in any situations) without asking and answering the questions: whom, when, where, and why or why not?

Science Talk

Rosebery, Warren, and Sylvan (1992) used the term *scientific "sense-making"* to signify the following beliefs:

1. Scientific ideas grow out of human activity and thought;
2. Such ideas are "constructed," rather than "discovered"; and
3. Scientific understandings are shaped by a community through reasoned scientific argument, rather than received from a scientific authority.

"Science talk" is the specialized discourse used among members of the scientific community to facilitate the communication of nascent ideas, questions, observations, and conclusions that contribute to the construction and sharing of scientific understandings.

The term "Science talk" will be used here to describe the language of the classroom interactions through which the construction of scientific ideas occurs. Through practice in the classroom or laboratory, which is scaffolded by the teacher, this explanatory language of inquiry evolves from "*informal* Science talk" to "*formal* Science talk."

Effective communication within the communities (which include Nobel laureates as well as toddlers in sandboxes) in which scientific understandings are constructed, requires some mutually comprehensible form of language. As the continuum of scientists extends from those in the sandbox to those in the laboratory, the complexity and scope of the phenomena being discussed demand increasingly efficient tools for communicating. Whereas "informal Science talk" is perfectly sufficient for the elementary concepts and observations common to young children, some thought must be given to the necessity to introduce more formal scientific terminology to children as the concepts and observations become more sophisticated.

Students who aspire to advanced coursework and careers in science will need to become fluent in the formal discourse of the discipline. When should teachers begin to build students' language skills in science?

Science Talk as a Non-Native Language

This study equates the acquisition of fluency in "formal Science talk" with learning to be fluent in any non-native language. It is just as unlikely that either will be learned in the context of the home, and certainly not among peers. This is why "formal Science talk"— the non-native language of formal, technical, Science-specific discourse — must be taught at school (Gee, 2004). As with any non-native language, instruction will be more effective in the primary grades. Failure to begin building awareness of this discourse in the primary grades robs the student of the foundation upon which increasingly sophisticated "formal Science talk" would be built. Again, some level of scientific inquiry is possible with informal, terminology; such inquiry becomes untenable, however, when complex explanations require extensive digressions from the study of the phenomenon under examination (Lemke, 2004).

What if we were to agree to view learning Science as if students were learning a non-native language? Learning the vocabulary of the academic language of school Science (LSS), in which both "abstract and common words can take on specialized meaning," is—as it is with any other language—necessary and integral (Lemke, 2004, p.)

One is empowered to proceed with an academic career in Science because of the "Science talk," that teachers and students begin to share at the elementary level. Rather than just asking the child to "do something," teachers promote deeper understanding through questioning and answering or discussing and clarifying through the language that is developed and shared during such interactions. Appropriate instructional designs at the elementary level will build students' confidence with Science to the point that they will choose Science courses once they reach high school. As Khisty and Chval (2002) write with regard to Mathematics, "to learn the subject, one needs to be able to comprehend this way of speaking mathematically. Since it is a specialized discourse that would not readily be heard in most social contexts, we can assume that it is not acquired in the same way as everyday language" (p. 156). The present study focuses on the semantic aspect (meanings of words, vocabulary). Syntax (relationships among words to form grammatical statements) will not be discussed. Khisty and Chval's (2002) conclusions can be applied successfully to the specific case of scientific discourse. That is, few children grow up in a social milieu within which the technical vocabulary of scientific discourse is heard. Such vocabulary, then, must be actively taught to students who want to pursue coursework or careers in Science.

Scaffolding the acquisition of the non-native language of school "Science talk" is an iterative process. Students' spontaneous questions and comments about Science express their curiosity about Science, and teachers must engage with students in very productive explorations of the scientific world (Warren & Rosebery, 1993). This engagement may incorporate "formal Science talk" in a highly scaffolded way. This may be necessary, according to the specific context of these discussions. The important point to remember here is that a student's question or comment should not be invalidated in the course of the discussion. Rather, it should be used as a teachable moment. The introduction of a new term in the process of discussing the concept with the student will not be an imposition on his or her patience; the student is the one who initiated the discussion and demonstrated an interest in the concept. When a student is interested in a topic and a teacher is inclined to encourage the student's interest and his or her willingness to initiate such discussions.

Science in action in the classroom has a distinct look and feel. As in the hypothetical discussion described above, there is a need for the teacher to encourage inquisitiveness in class (Warren & Rosebery, 1993). One way to encourage scientific thoughts, questions, and comments is to expand students' opportunities for reading and writing that include use of age-appropriate "formal Science talk" — the formal vocabulary that lies at the students' zones of proximal development — in academic contexts. As the students' zones of proximal development gradually "slide" up the scale of learner-directed learning, the teacher monitors and adjusts the language used in instruction. Typically, however, the scope and sequence of mandated curricula are meant to be aligned to the students' zones of proximal development. The scaffolded, mediated use of "formal Science talk" takes place within the context of the curriculum, the specific objectives being taught (and about to be taught), and the teacher's professional assessment of each student's readiness to accept varying levels of semantic challenges. At no point should the teacher attempt to introduce formal scientific vocabulary for topics beyond the scope and sequence of the mandated curriculum.

Instructional strategies that facilitate the acquisition of "formal Science talk" include discussing content, writing summaries, and building technical vocabulary. These activities surround and are supported by students' reading of authentic documents that include, but are not limited to, textbooks, academic reports, charts, graphs, and other available reliable sources of scientific information.

As a result students will be introduced to the elements necessary for understanding the language of school Science, which, in turn, is necessary for inclusion in the culture of Science. Conscientious use of "formal Science talk" in the classroom can make that happen. Eschewing "formal Science talk" for fear of confusing students, losing their interest, or for any other possible reason, does not help the student acquire the language skills necessary for eventual coursework and employment in Science.

"Natural language," then, is shown to be a necessarily limited domain of discourse. Practically speaking, natural language is sufficient for most people. For those who aspire to professionally conduct experiments, to test the world, and then to report to the world their findings, however, there is an "expansion pack" of vocabulary words specifically and systematically designed from common root words and with common affixes for that very purpose. In order to enjoy the fruits of the scientists' labors, one only needs to be able to participate in the dialogue being mediated by teachers in classrooms all across the world.

Mediated Dialogue: Questioning, Defining, Clarifying, Evaluating, etc

Bloom's Taxonomy, a popular instructional model, was created for categorizing the levels of abstraction of questions that teachers use. It provides a useful structure to categorize questions, from lower order to higher order of complexity within particular levels. With consistent use of it students will begin to develop an understanding of the levels of questions that will encourage them to use appropriate learning strategies. This is similar to what Palincsar and Brown term "reciprocal teaching," during which students might learn comprehension strategies. "Reciprocal teaching" has been successful, but only when teachers believe its underlying assumption that collaboration among teachers and students to construct meaning, solve problems, and so forth, leads to higher quality learning (Palinscar, 1986).

Bloom's Taxonomy divides the way people learn into three domains (the cognitive, the affective, and the psychomotor) but the one pertinent to this study is the cognitive domain. The cognitive domain punctuates intellectual outcomes and is further divided into categories or levels (higher- and lower-order questioning). Throughout the mediated dialogue the key words used and the type of questions asked will aid in the establishment and encouragement of critical thinking, especially at the higher levels. Figure 2.B below, illustrating the levels of Bloom's Taxonomy, was adapted to show the transition levels of technical vocabulary usage in a classroom "filled with words —rich words — that students appropriate as their own, use as tools for their thinking and use as tools to communicate their thinking" (Khisty & Chval, 2002, p. 154).

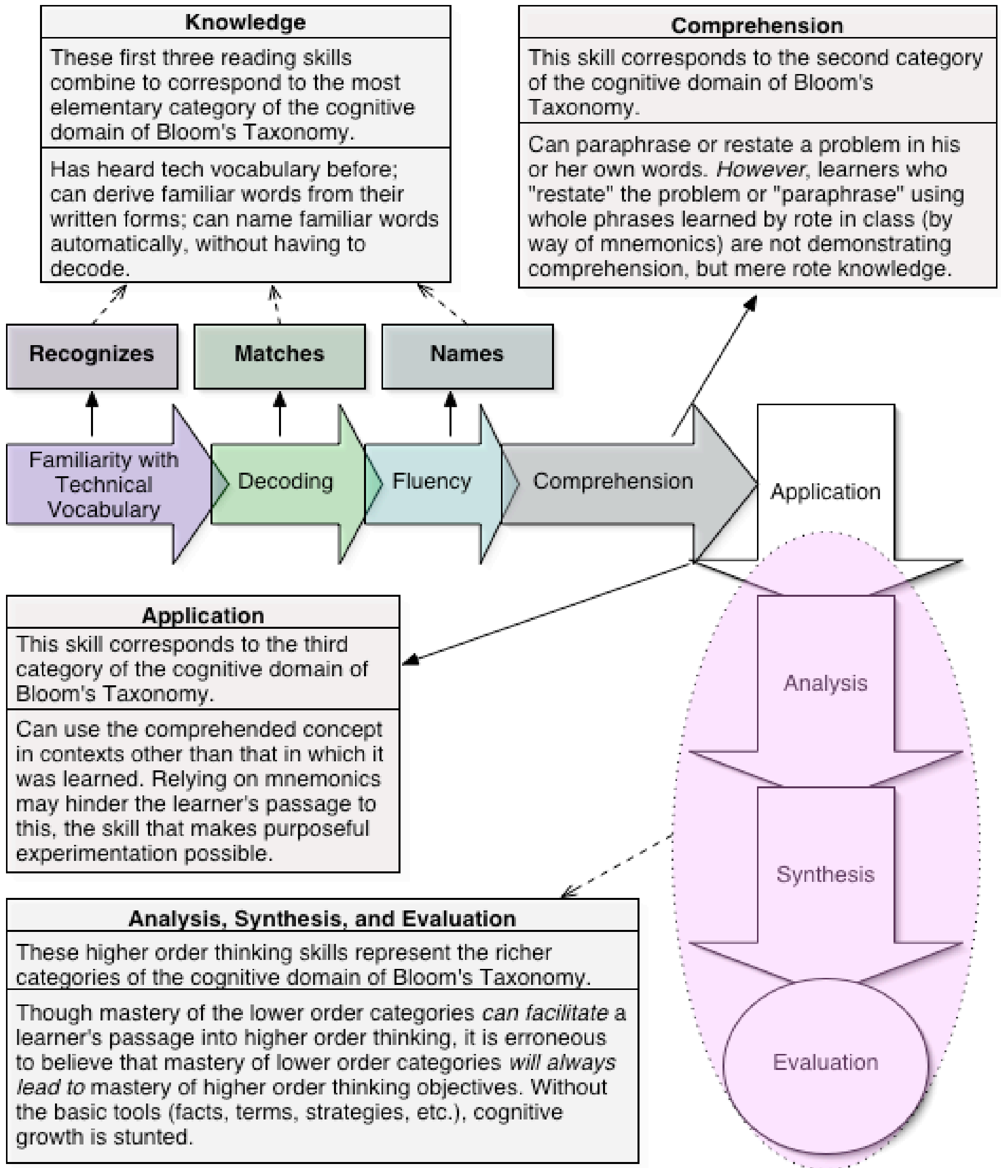


Figure 2.B. Bloom's Taxonomy as it relates to how a teacher should transition from lower-order to higher-order questioning in a classroom rich in Science Academic Language (SAL) and full of teacher-students interactions.

As indicated by Bloom's Taxonomy (Figure 2.B), evaluation is the highest level of cognitive learning. In order to attain the ability to evaluate, learners must first master the lower levels of cognitive learning with regard to the specific content being addressed. In Science, as in other disciplines, comprehension is a necessary component of higher levels of cognitive learning. A student can, indeed, grasp concepts (comprehend) without formalized discourse tools (such as science-specific vocabulary). However, progressing beyond mere comprehension is considerably simplified for learners of Science who have mastered the language (vocabulary) used to represent both the concrete and abstract elements of scientific inquiry. Again, evaluation is possible for any student who comprehends the constituent concepts, provided he or she has also mastered the requisite cognitive abilities.

Formal explanations are, in this case, the vocabulary that, by virtue of its density, permits learners and their teachers to discuss scientific topics without getting lost in *informal descriptions* of the concepts being discussed. Formal explanations enhance understanding and mobility of objects (concepts) by simplifying the syntax of scientific statements. Short, denser, more sophisticated semantics can result in broader, simpler syntactic constructions.

Through teacher-mediated dialogue (the introduction of new, technical language and practice of it) learners and teachers form networks of influence throughout the classroom (and, arguably, beyond) (Khisty & Chval, 2002). Each voice in the room influences other voices, and is influenced by them—action and reaction.

Khisty and Chval (2002) corroborate these assertions about the nature of using language in order to own it, noting that:

> The words represent meanings that are waiting to be developed and eventually internalized. Therefore, which words are presented to the students and how they are developed are vitally important. Just as important is that students have opportunities to use these words in their talk as they work (p. 155).

It is through these multiple, language-rich opportunities that students gain a firm grip on the meanings and appropriate uses of the technical language of school Science. This is commonly referred to as fluency. Fluency is automatic word recognition with accuracy and speed. “Formal Science talk,” in turn, requires some degree of fluency in the technical vocabulary of the domain, e.g., Nature of Science, Life Science, Earth Science and Physical Science. “Formal Science talk” requires more than just fluency in the technical vocabulary of the domain, but it is helpful (Lemke, 1990). The other elements of “Science talk,” however, are not the focus of this study. The elements relating to *syntax*, or the rules of grammar for constructing scientific statements, are beyond the scope of this study. Questions of *pragmatics*, or the changing meanings of words across different contexts, also lie beyond the scope of the present study. Though there do exist a number of technical Science terms that have other meanings in contexts other than “Science talk,” I will only be addressing the meanings of those words within the context of “Science talk.” Meanings they may have in other contexts are not relevant to this discussion of “Science talk.” It is only *semantics*, the meanings of individual words, i.e., *vocabulary* that is to be addressed with regard to elements of “Formal Science Talk”.

Figure 2.C below presents forms of communication that one could expect to see in an effective Science classroom:

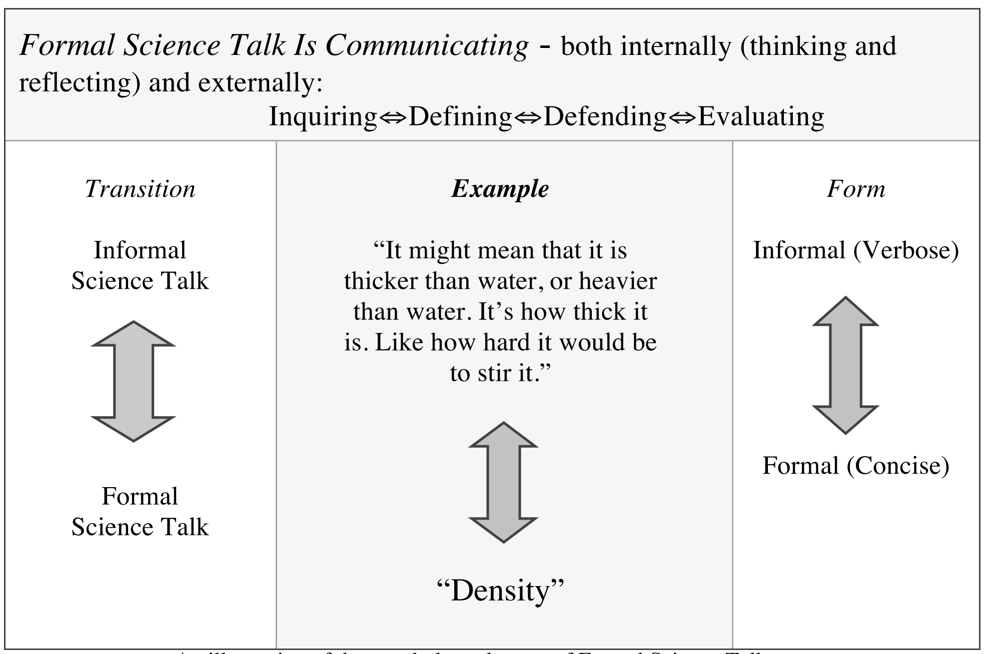


Figure 2.C. An illustration of the vocabulary element of Formal Science Talk

Figure 2.C illustrates the vocabulary elements of “Formal Science Talk.” Appropriate use of the technical vocabulary is integral to the process of learning to inquire, define, defend, and evaluate. These four action words reflect the key cognitive skills for which formal vocabulary can be most helpful:

1. Inquiring
2. Defining
3. Defending
4. Evaluating

The process of learning these four cognitive skills is facilitated by the teacher's use of vocabulary-building strategies throughout the lesson cycle. Table 2.1 (below) contains examples of vocabulary-building strategies that could be employed at different points in a lesson. The examples below are for a kindergarten Science lesson.

Table 2.1: From a Caterpillar to a Butterfly

Before Read *The Very Hungry Caterpillar* by Eric Carle. Discuss the changes that occur in the story. The words *caterpillar*, *cocoon*, *chrysalis*, and *butterfly* are used in the story. Ask students how these words are used in the story. What do they think these words mean?
During As you introduce students to the terrarium that contains water, milkweed, a patch of sod, and a live caterpillar, ask students what the caterpillar will eat and drink. What else will happen? Record their words on a chart tablet, illustrate the words, and use this to help students discuss their predictions of what will happen in the terrarium. Over the course of this unit, read nonfiction books about metamorphosis. Discuss how the words and ideas in these other books relate to what the students already know about metamorphosis.
After Once the butterfly has emerged from the cocoon, give students multiple opportunities to describe what has occurred. They may use the chart tablet notes as reference. When a student does not use the applicable vocabulary, invite him or her to use the term. If he or she has forgotten, invite the others to "help" by providing either cues or the actual words themselves. Upon releasing the butterfly as a class, allow students to individually draw or write about what happened. Take dictation from each student and write their words next to their drawings. Encourage students to use their new vocabulary for what they've drawn. Ask them to share their drawings with their parents when they get home.

This table was adapted from a discussion with a friend who was a kindergarten teacher for three years.

Where does knowledge, fluency, and control of the social language of school Science come from? It is created in the classroom, from interactions that the teacher scaffolds and models, as in the example lesson cycle in the table above. It is the teacher who assists the students across the bridge from scientific illiteracy to fluency in the discourse of Science. Next, since the vocabulary is being taught within the context of applicable lessons on the scientific concepts—during and parallel to content lessons—the students are simultaneously being taught the subject matter they will be expected to discuss and the vocabulary that will make those discussions more meaningful and less frustrating.

In a discussion he published on the Internet, Stephen W. Draper (2003) makes the case for consistently using formal "Science talk": "For instance, I recently used the word 'neurophysiology' in an exam question. What reason do I have for believing the students knew what it meant? I can't remember telling them. And if they didn't know, then the whole question reduces to a trivial surface test of vocabulary."

The vocabulary components of instruction help learners to gain a conceptual understanding as they learn the vocabulary, and vice versa. Students learn to understand the concept as they gain understanding of the meanings of the words. Students grasp words better when they have a cognitive understanding of the concepts they are exploring.

Vocabulary Teaching Strategies

Numerous studies have found that scaffolded learning in a collaborative setting helps to improve learning among students from groups that traditionally underachieve (Delpit, 1994; Jensen, 1969; & Ladson-Billings, 1995). Table 2.2 highlights moments within the context of teaching Science that the teacher could integrate into strategies for teaching vocabulary.

Table 2.2: Explicit and Systematic vs. Teachable Moments

Explicit and Systematic
Analogy*:* Teaching students the meaning of science terms by comparing a part of the unknown term to similar parts in known terms. Analytic*:* Teaching students to determine the meaning of an unknown word by finding each part of the unknown term words for which the meaning is known. Unlike the Analogy approach above, all parts of the unknown word are analyzed, so that no part of the unknown word escapes the process. Synthetic*:* Explicitly teaching students the technical vocabulary needed for that particular concept, to include direct instruction in the base or root words they will encounter, as well as the common prefixes and suffixes associated with them. Examples: 1) *monoxide,* with "mono" meaning *one* and "oxide" meaning *with oxygen* 2) *dioxide,* with "di" meaning *two* and "oxide" meaning *with oxygen* 2) *cephalopod,* with "cephalo" meaning *head* and "pod" meaning *foot* 4) *gastropod,* with "gastro" meaning *belly* or *stomach* and "pod" meaning *foot* 5) *arthropod,* with "arthro" meaning *joints* and "pod" meaning *foot*
Teachable Moments
Embedded*:* Teaching students the technical science terms when the term incidentally appears in the text used during the lesson, or when students ask questions that signal their readiness for the new terms. Analogy ⇔Analytic ⇔Synthetic

Technical Vocabulary Instructional Approaches: This table was adapted from reading research.

Is "Formal Science Talk" another barrier that perpetuates the exclusion of many students of color from advanced coursework and careers in the hard Sciences?

The language of Science is neither proprietary nor exclusive. It is available and attainable to any person motivated to learn it. Once learned, however, the language of Science bridges the gap between the peripheral consumption of Science for amusement's sake and the fundamental consumption of Science for productive ends. Lemke (2004) warns against dismissing leisurely forays into scientific topics: "How [students] choose to read depends on the context of the activity and their current agenda, but even this can surprise us because people can be serious and critical even in their leisure activities" (p. x).

Lemke (2004) also points out a noteworthy distinction between scientific discourse as a discourse of exclusion (or power) and scientific discourse as a specialized discourse of efficient communication (or empowerment):

> The language of science is a unique hybrid of natural language, as linguists define it, extended by the meaning repertoire of mathematics (the set of possible meanings that can be made with mathematical symbols and the conventions for interpreting them), contextualized by visual representations of many sorts, embedded in a language (or, more properly, a semiotic) of meaningful, specialized actions afforded by the technological environments in which science is done (p. 33).

The Importance of Bridging "Informal Science Talk" and "Formal Science Talk"

Two common statements of the Science Education reform movement, "Science for All" and "Scientific Literacy for All," reflect notions embedded in the National Science Education Standards. The teacher is at the center of the movement towards educational reform; and discussion often focuses on what she or he must know and be able to do in the classroom. More and more teachers are accountable for the achievement of their students, and teachers' efforts to that end are measured through standardized student examinations that are written in the dominant discourse of expository texts. To achieve success and/or proficiency, as reflected in scores on standardized achievement tests, all students must be literate in the dominant discourse of expository texts (Holliday, 2004). It behooves teachers in at least three regards, then, to ensure that their students become fluent Science readers and speakers:

1. In the short and intermediate terms, fluency in scientific discourse—technical vocabulary—serves as a foundation for the accumulation of new scientific knowledge and for the extension of mastered scientific knowledge into situations requiring higher order thinking (application, analysis, synthesis, evaluation);
2. In the short and intermediate terms, fluency in the dominant discourse of scientific expository texts ensures the speedy and accurate reading of such texts, including achievement tests, the scores of which may be used to monitor teacher effectiveness; and
3. In the long term, fluency in the dominant discourse of science opens many doors for students when Science-related opportunities knock. Without a firm grasp of the language of school Science, students simply will not be qualified to pursue further studies or career opportunities in the hard Sciences.

Teachers, and the instructional strategies they utilize to help students bridge the domains of "saying it their way" and "saying it the formal way," are key components of the teaching and learning process (Delpit, 1995). There are accommodationist researchers and classroom teachers who are satisfied with students "saying it their way" and who argue that understanding does not necessarily require the vocabulary of the domain. This limited approach expects little from the students beyond knowledge and comprehension objectives; they believe that students' ability to parrot back memorized definitions or explanations is evidence of effective teaching and learning.

Though Delpit's (1995) seminal work on the politics of teaching the literate discourse—or the *dominant* discourse—is not ostensibly about Science, it does lend itself to what occurs in a classroom where different cultures coexist and where students are expected to learn and perform proficiently on state mandated exams. Delpit utterly disagrees with accommodationist educators, stating that, in the real world — the one that exists outside of the classroom – there are "literate" communities that only accept those who can manipulate the language of the domain. "Saying it their way" is a place to start, with the teacher taking the role of mediator to help the students translate their way into what is deemed standard in Science. This forms a solid foundation of understanding, so that students may later have the linguistic tools they need to converse with others beyond the classroom. Using simplified language in this way is the first step—but only the first step—in scaffolded instruction.

The progression below (adapted from Driver, et al., 1994) is an example of this scaffolding from simplified, common language to Formal Science-specific language and symbols (artifacts). This lesson on the nature and properties of sunlight had already included an activation of prior knowledge and a listing of observations about sunlight:

I. After a guided discussion, the students reached a consensus on the notion that light "keeps carrying on." After that sequence of discussion and consensus building, the teacher then began using the words "ray of light" to describe the path of light. He further introduced the students to the conventional, symbolic representation of the light ray.

II. The term "ray of light" and the arrow-like notation that represents a ray are examples of cultural tools (language and symbolic representations) or artifacts of Science. It is reasonable that students be expected to use these tools in subsequent lessons and discussions, or to be able to read them in a textbook or write them on an exam. Such is the nature of literacy; and specifically in terms of scientific artifacts, such is the nature of scientific literacy.

Vocabulary Acquisition

Currently, Science Education focuses on the importance of introducing concepts rather than on the development of students' Science vocabularies, which limits their abilities to discuss or verbally manipulate those concepts. However, in reading and language arts, research shows that repeated use of vocabulary through oral and written communication is one way to get students to "own" these terms. Those terms —and the concepts they represent — then become portable, and can be used, discussed, and applied as opportunities present themselves.

Few Science teachers are formally trained in matters of vocabulary; vocabulary acquisition and development, and effective vocabulary instruction, must therefore be gleaned from research in reading and language arts. Vocabulary knowledge has a significant impact on comprehension (NRP, 2000). How do students acquire vocabulary? Which scientifically based instructional strategies have proven most effective?

Comprehension strategies developed in reading and language arts can and should be transferred to the explicit instruction of comprehension skills in Science. Such transference would be effective because Science texts, instructional materials, teacher language, and standardized tests are not narrative, but expository. Students are expected to read and comprehend expository materials, which are typically written with more complex, abstract vocabulary than narrative texts or simplified instructional materials (Holliday, 2004). An illustration of the differences between these two forms of written discourse is provided below:

Table 2.3: Narrative and Expository Texts

Aspects of the Written Matter (Text)	*Narrative*	*Expository*
Tells a story	Y	N
Is a textbook or another type of informational text	N	Y
Incorporates figurative language	Y	Y
Contains headings, graphics, and titles	Y	Y
Includes content-specific language	N	Y
Uses highly dense vocabulary	N	Y

Adapted from Third Grade Teacher Reading Academy: Semantic Feature Analysis, Copyright © 2003 UT System/TEA.

Table 2.3 represents the differences between narrative and expository texts. The features of both forms of discourse are listed down the left-hand column of the table. The clear boxes containing a capital Y indicate that the correlating feature is positively associated with that form of discourse. The shaded boxes containing a capital N indicate that the correlating feature is not associated with the form of discourse.

Students who are expected to learn from expository texts must be equipped to decode content-specific language and highly dense vocabulary. As it is unlikely that language arts teachers will provide direct instruction on either Science content–specific language or highly dense scientific vocabulary, the responsibly for providing that instruction falls to the Science teacher.

Teachers, schools, and districts often cite “self-directed, lifelong learning” as an integral part of their mission vis-à-vis the students they teach. Figure 2.D below illustrates how substituting simplistic mnemonic devices for technical descriptions using technical vocabulary actually precludes any notion of “self-directed, lifelong learning” for the affected students.

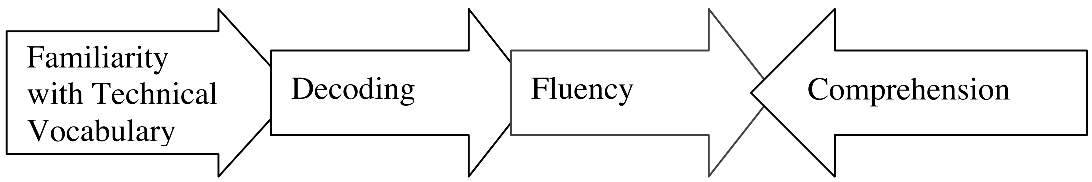


Figure 2.D. Continuum of Elementary Skills Required for Effective Reading to Learn in the Sciences adapted from the Texas Reading Academies.

This continuum of skills provides an elementary view of what takes place when students attempt to read Science-related texts. It is aligned closely with the conceptual continuum known to most reading teachers, though the reading teachers would expect to see “phonemic awareness” instead of “familiarity with technical vocabulary” in the first space. This is an acceptable substitution, as both represent the learner’s ability to recognize, segment, and say the following:

- the words that comprise sentences,
- the syllables that comprise words, and
- the phonemes that comprise syllables.

If a learner is not familiar with the words “cat” and “mouse,” then the learner may not recognize them as distinct parts of a sentence, and will not be able to understand the sentence in which those words appear. Likewise, a student who is not familiar with the word “dehydrohalogenation” will probably fail to understand the sentence in which that word appears.

However, the student who knows that words such as “cat” and “mouse” and “dehydrohalogenation” exist will, upon encountering such words in written matter, be able to sound out the letters in order to recreate the constituent sounds. Recognizing that the sound of the word approximates the sound of a familiar word, the student can then move on through the remainder of the sentence in order to see how that word relates to the other words. This strategy is called “decoding,” and its success relies very heavily on the student’s working vocabulary (TRA, 2003).

The quicker the student can decode the individual words of a sentence, the more the sentence will resemble spoken language. This provides a rhythmic context for the word, aiding in both rate and accuracy of reading. Rate and accuracy combine to facilitate comprehension, or the meaning that the reader is trying to extract from the written text. As comprehension increases, it contributes to the inflection that the reader can impart, increasing rate and accuracy even more. This chain reaction can only take off if the student already possesses the oral vocabulary needed to successfully decode the written word (Lemke, 1990).

An Example

If the concept of dehydrohalogenation had been addressed in Science class two weeks ago, but was only taught that it means “turn down acids, take away salts,” then the student is effectively prevented from accumulating any further knowledge on his or her own from books. The student has been robbed of the vocabulary needed to comprehend related texts he or she reads beyond the classroom environment. “Self-directed, lifelong learning” becomes a meaningless catchphrase.

“Reading to learn” begins in earnest in the fourth grade. Students recognize that one purpose of reading is to learn more about Mathematics, Social Studies and Science. The process of extracting subject-specific knowledge from texts is not automatic, but must be taught and scaffolded (TRA – 4th Grade).

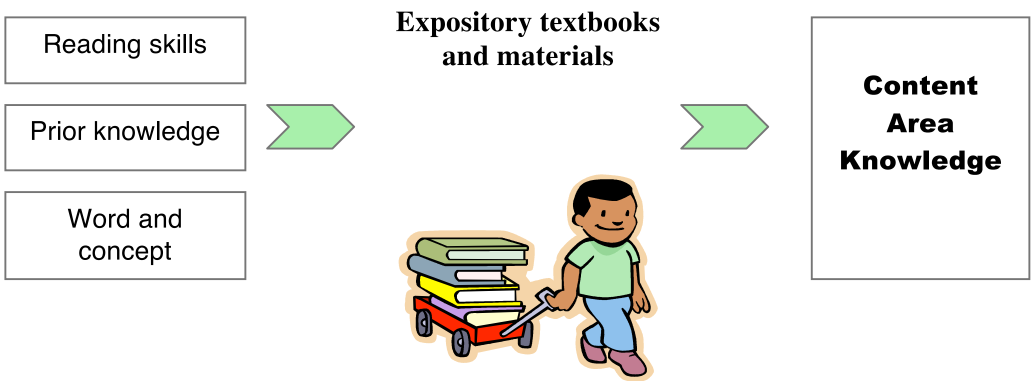


Figure 2.E. Developed by researcher for illustration from the ideas of reading a Science text book, standardized tests, and listening to scientists.

The catalyst for the process above involves six discrete instructional steps:

1. Activate prior knowledge;
2. Introduce the strategy;
3. Think aloud while demonstrating the strategy;
4. Scaffold learning and recall steps as needed (formative assessments);
5. Think-pair-share or other guided practice with the strategy; and
6. Constantly monitor students' understanding and provide feedback (summative assessment).
7. Repeat steps 3-6 as necessary until students master the strategy.

A Focus on Vocabulary in Science

There is research in Science Education, which merges the domains of Science and literacy. There are considerable writings in the field, from *The New Scientific Literacy* to *Crossing Borders in Literacy and Science Instruction* (E. Wendy Saul, ed., 2004), but it is still a challenge to find literature that addresses how to develop a scientifically literate population through vocabulary acquisition, development, and appropriate usage specific to any field in Science.

There is little research that emphasizes the importance of vocabulary for comprehension in Science learning. But with an emerging interest among Science Educators to focus on the directly proportional relationship between vocabulary and comprehension, perhaps more researchers and practitioners will begin to see the connection. How much more needs to be done and how to do it depends on a variety of factors, not least of which is the recognition among Science Educators that their colleagues in the language arts have discovered a pleasingly scientific theory: If a student has mastered the technical vocabulary of Science to the point of automaticity—that is, to the point that she can use that vocabulary unconsciously, just as a writer can compose essays on a computer without having to consciously think about where the "w" key is—then expository texts that explain concepts new to the student using that technical vocabulary will not overwhelm her.

SUMMARY

"The Wound" refers to a state of population-specific inequality. Can we accept that the civil rights issue of our time is the "achievement gap?" The achievement gap between minority and majority students exists in all areas of the standardized testing spectrum. There are Science Education researchers calling for us to problematize issues that punctuate student achievement, specifically those students who have been consistently failing in the existing education system.

Therefore, this study was focused around a theoretical framework of teaching and learning Science that advocated for teachers uses of scaffolded instruction when teaching the vocabulary. More importantly, teachers' instructional designs will include explicit and systematic science vocabulary teaching strategies.

In the case of this study, the issue that will be carefully studied is the technical vocabulary usage in one teacher's Science classroom. The chapter that follows provides descriptions on the selected research design.

Chapter III: Methods

INTRODUCTION

Preparation for success in Science begins in the elementary grades. It is expected that students' knowledge base will grow with each year of instruction. The learning process begins with concrete examples of phenomena that occur in nature and works up to providing students with explanations of abstract phenomena and helping students to understand them. As students mature, students build a vocabulary of Science they will need to successfully complete examinations and more advanced classes. This study will focus on the instructional strategies of one elementary Science teacher specialist, and will document and analyze her efforts to establish in each of her students the vocabulary necessary for the study of Science in high school and beyond.

I originally proposed to spend between five and nine weeks with Ms. Jones and her fourth or fifth grade class at Ready Elementary School, which is located in the southeast section of a major city in Texas. For the actual study, I spent between 18 to 21 per week in Ms. Jones' fourth and fifth grade classrooms for four weeks at the end of the 2004-05 school year and for three weeks during January and February 2006. Videotaping the classroom and laboratory instruction enabled me to record and scrutinize the interactions between Ms. Jones and her students, and student-to-student interactions, as Ms. Jones and her classes moved from whole-class discussions to small-group discussions. The analysis focused on Ms. Jones' interactions with her students. I collected data using field notes, videotapes, audiotapes, the teacher's written explanations of strategy choices, samples of teacher-prepared questions, and district and state assessments. Transcripts of some of the videotapes and audiotapes were prepared. This multi-pronged approach was, as Stake writes, "a search for understanding of things happening more or less at the same time" (Stake, 1995).

Alignment with the Theoretical Framework

Definition of a Case Study

A case study is an inductive approach to understanding an observable phenomenon. By emphasizing observation and analysis of just one example of the subject phenomenon *in practice*, the case study allows the researcher to examine not only the individual parts of the complex whole, but the interdependent relationship among those parts as well—the "spaces in between." For this study the case was Ms. Jones and her students. Of particular interest were the interactions that occurred as Ms. Jones helped her students to transition from informal to formal science talk through scaffolding.

According to (Stake, 1994), triangulation of data sources allows for clarification of meaning and verifies interpretations. A case study requires multiple forms of evidence, which are triangulated to produce a richer picture of the phenomenon under investigation. One set of data were derived from semi-structured interviews:

1. A pre-observation, semi-structured interview with Ms. Jones
2. Intermediate and post–observation, semi-structured interviews with Ms. Jones
3. A semi-structured interview with the novice teacher, Ms. Drinks

Semi-structured interviews were used to confirm data collected from the classroom observations. During these interviews, the respondents were questioned for an hour; they answered prepared questions as well as additional questions interjected by the researcher following up on teacher responses. One semi-structured interview was conducted with Ms. Drinks, the novice fourth grade teacher who was present and was a source for scaffolding in the laboratory with Ms. Jones. Ms. Drinks was absent on one observation day. Also, she took the role as instructor one day when Ms. Jones attended a meeting.

Videotaping of classroom observations provided another source of data. Videotaping allowed direct observation and data collection following established protocols. Full-group and some small-group discussions were recorded. Ms. Jones wore a wireless microphone so that everything she said could be captured (Data Set 1).

A third source of data came from verbatim transcriptions of all audiotaped interviews and one classroom observation. The first two hours, in their entirety, and subsets of the rest of videotapes from Data Set One – Spring 2005 were transcribed. In this study these transcriptions are used as the source of evidence of anticipated and emergent themes centered around the study's focus on scaffolding and technical vocabulary usage.

Finally, contents of the following artifacts were analyzed for technical vocabulary:

1. Handouts
2. District Instructional Planning Guide
3. TAKS information booklet
4. Supplementary questions that were developed by Ms. Jones and used to assess student comprehension of the topics.

Rationale for using a case study research design

When one analyzes quantitative data drawn from standardized examination results, the reasons for the failure or success of minority students are buried under the weight of the large sample size. One way to discover factors underlying student performance is to conduct a small-scale study in which detailed observations of students with their teacher in a classroom setting yield insights into individual success or failure. I used a case study because the method is appropriate when "investigators desire to a) define topics broadly and not narrowly, b) cover contextual conditions and not just the phenomenon of study, and c) rely on multiple and not singular sources of evidence" (Yin, 1993, p. xi).

The teacher scaffolds the transition from "informal Science talk" to "formal Science talk." Since the aim of this study was to provide an authentic interpretation and understanding of the instructional strategies one science teacher used in order to elevate her students' Science talk, the qualitative research method best suited for this instance was a case study. The case study method allowed for an in-depth and comprehensive understanding of Ms. Jones' use of instructional strategies that helped her students transition and/or grow as they began to integrate Science vocabulary into their world view. A case study also allows for an extended period of time to be spent with the subject(s) being examined. This extended observation period was critical, because science lessons in the observed classroom were grounded in the "Five Es Model," which the district incorporated into its guidelines for lesson planning. The five Es are, in order, Engage, Explore, Explain, Elaborate, and Evaluate. The five Es unfold over time and are essential to evaluating student growth (changes in vocabulary usage meaning less in the beginning and more at the end) from beginning to end, for both short-term (one class period and /or one week at a time) and long-term (full length of the study) extended observation periods. Hence, the case study research design was clearly the most appropriate choice for this particular study.

Choosing one teacher for the study

In choosing a teacher to study, I reflected on my own philosophy of teaching and the kind of teacher it would take to challenge me to modify, build upon, or expand that philosophy. I was seeking a better understanding of teacher scaffolding that would help students develop a discourse pattern (Delpit, 1988; Warren and Rosebery, 1994) that had the language of school Science (LSS), with its technical vocabulary, as an integral piece. I am particularly interested in improving the accessibility of high school "hard Science" courses to underrepresented children. In so doing, I focused on the possibility that increasing an individual's access to scaffolded and appropriate Science instruction can make the difference between preparedness and unpreparedness for learning Science during and after school.

I sought to find a teacher whose classroom was filled with language. I was introduced to Ms. Jones by one of my professors, who thought she might be an appropriate subject of a study about science, language, and vocabulary. Ms Jones proved to be the kind of teacher who continues to refine her philosophy as an educator. She has a passion for teaching that inspires teachers and students alike. In her daily activities as a Science teacher she teaches elementary students ranging from first grade through fifth grade, while modeling instructional practices for other teachers. Academically, she possesses a bachelor's and a master's degrees in Science Education, and has had with additional schooling in chemistry and physics.

The Emergent Design

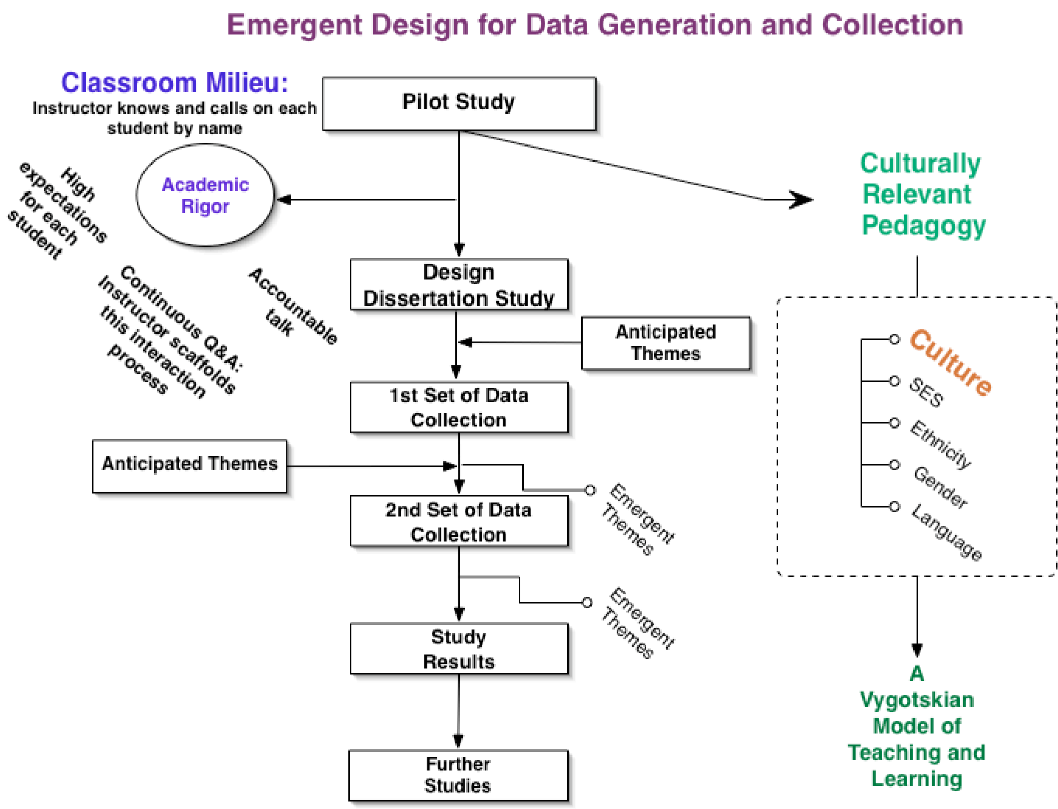


Figure 3.A. This diagram shows the conceptualization of the study from pilot study to two sets of dissertation data generating and gathering. (SES is socioeconomic status.)

Explanation of the diagram:

1. Pilot Study

The purpose of this study was to determine the types of pre-college and in-college educational and life experiences that promote the continued participation in Science by students from various ethnic groups. The work focused on freshman students in a Chemistry class sponsored by the University Interdisciplinary Plan (UIP).

Three driving questions framed the purpose of this study:

i. What encouraged students participating in the University Interdisciplinary Plan Chemistry class to persist in the study of Science in high school and college?

ii. What if any discouragement did these students face in their pursuit of studying Science in college?

iii. What should be considered when developing interventions to increase students' participation in Science in college?

The following ideas emerged from the pilot study to guide this larger research:

a. Academic Rigor

   i. Accountable talk: The instructor expects students of all backgrounds to eventually use the technical language of Science in class and to embed that language into the classroom culture.

   ii. Class culture will include all of the following aspects of CRP, but the instructor whose expectations reflect academic rigor will insist that the technical language of Science be added to the other aspects.

b. Culturally Relevant Pedagogy: Instructor is cognizant of, and knows how to teach, Science in response to student-specific needs, as reflected in the students' culture, which includes SES.

   1. Cuts both ways, but this study will emphasize the needs of students from generational poverty.

   2. If underrepresented students of color can often be assumed to come from backgrounds of generational poverty, then it makes sense to concentrate on what constitutes CRP for this population.

   3. Such generalizations are not meant to imply that all Black students and Hispanic students have the same needs vis-à-vis CRP, but they do recognize that addressing the generalized problem will be most useful to a larger subset of the population of students of color.

2. Ethnicity

   i. Ethnicity is but one variable within the population of "children of color."

   ii. Black students from the Caribbean have needs that are different from those of Black students from Africa, Black students from rural America, and Black students from urban America.
   iii. Hispanic students from the US/Cuban culture have needs that are distinct from those of Hispanic students from the Cuban island culture, Hispanic students from the US/Mexican culture, Hispanic students from the Mexican national culture, and Hispanic students from the rural America culture.

3. Language
   i. The language variable is even more fragmented than the ethnicity variable, as it can vary not only among ethnicities, but also among geographical dialects, SES, and accustomed register (continuum from informal-verbal to formal-written).
   ii. As with SES and ethnicity, a broad spectrum of language variances may be present in a single classroom.
4. Gender

   With respect to all of the foregoing variables, which should be considered when formulating CRP, gender-specific needs may vary within each sub-subgroup of the student population in any given classroom.

   i. In addition to cultural perspectives of "normal" gender, there may be other perspectives for students of GLBT (gay, lesbian, bisexual, transgender) orientations.
   ii. Nuances of cultural perspectives regarding gender are potentially the most difficult for teachers to grasp.
      1. Little research into the multifarious attitudes may be available for the many ethnicities and the SES strata within those ethnicities.
      2. Many cultures are extremely reluctant to talk about gender issues, further hampering the educator's efforts to understand (and therefore formulate an appropriate CRP).

iii. All of the foregoing, as artifacts (seen or unseen) of the students' culture, are relevant to any discussion of Vygotskian co-constructions of knowledge in the classroom (universal).

iv. Instructor knows students by name (universal).

Data generation and collection

The instances for data generation and collection were gathered in the following contexts:

1. Whole-class: The first 15 minutes of the Science class began with the students sitting down on the floor as a group. The teacher began by asking questions and discussing what would occur during the small group sessions. She used this time to search for prior knowledge, set the stage for what was to come, and introduced some of the vocabulary.
2. Small-group: Students worked together, discussed and in many instances came to a consensus understanding of the activity (experiment). Also, students wrote in their interactive journals. The teacher worked with each group, asked questions and provided explanations and feedback orally and in writing.
3. Teacher interviews: There were a series of one-on-one interviews between the researcher and teacher. The questions initially focused on getting background information about the teacher's education (preparation) for teaching science and progressed to focus on the teacher's elaboration on her understanding on how students learned as well as what a teacher should know and be able to do. Over the series of interviews, some questions were repeated to see whether any changes have occurred --- Pat Jones was consistent in her answers. For example, such questions were about her philosophy on teaching, "science for all," "scientific literacy for all," etc. I conducted three face-to-face and two online interviews throughout the course of the study. One face-to-face interview was conducted with the novice teacher [Data Set I – Only].

4. Supplementary information: This included data on the demographics of the class, school, district, and state. The demographic breakdown is supplied in Table 3.1.

The breakdown of students and teachers by ethnic background is as follows:

Table 3.1: Students and Teachers

<table>
<tr><th></th><th>African American</th><th>American Indian</th><th>Asian/Pacific Islander</th><th>Hispanic</th><th>White</th><th>Total</th></tr>
<tr><td>This class</td><td>5.6%</td><td>0%</td><td>0%</td><td>94.4%</td><td>0%</td><td>18</td></tr>
<tr><td>This school</td><td>8%</td><td>0%</td><td>< 1%</td><td>88%</td><td>4%</td><td>854</td></tr>
<tr><td>District average</td><td>14%</td><td colspan="2">3%</td><td>52%</td><td>31%</td><td>78,155</td></tr>
<tr><td>State average</td><td>14%</td><td>< 1%</td><td>3%</td><td>43%</td><td>40%</td><td></td></tr>
</table>

Teachers

<table>
<tr><td>This class</td><td>1</td><td colspan="3"></td><td>1</td><td>2</td></tr>
<tr><td>This school</td><td>5%</td><td>0%</td><td>0%</td><td>39%</td><td>56%</td><td>60</td></tr>
<tr><td>District average</td><td>7%</td><td colspan="2">2%</td><td>22%</td><td>70%</td><td>5,382</td></tr>
<tr><td>State average</td><td>9%</td><td>0%</td><td>1%</td><td>18%</td><td>72%</td><td></td></tr>
</table>

This table was adapted from publicly available data on schools (Texas Education Agency 2004-2005). The average class size is 18- 21 for this school and 19 - 22 for the state.

Data Analysis

This study matured through a series of organizing concepts whose terminology are defined in Table 3.2, which was created to introduce the reader to the terms that would be used. I looked at the data as a whole (termed global) and then broke the study into these chunks, which I have characterized as segmented. Here is the terminology I used and how I used it:

Table 3.2: Definition of terms used to conduct a series of analysis

Term	*Definition*
Tacit Questions	Implied questions that mediated the development of the explicit research question. These questions were used to guide observations and served as the focal point for analysis of the teacher and instructional milieu.
Explicit Question	Comprehensive study question answered through this formal exposition. This is the question that stimulated the development and implementation of the coding scheme that revealed the findings of the study.
Global	This is all the data. All the data provided a picture of the classroom, the teacher and the students inclusive of decorations, interactions, interruptions, a beginning and an ending of each session, equipment (instructional and science), furniture arrangement, group structure and individual student interaction with Ms. Jones.
Deconstruction	Breaking down all the data into chunks to be analyzed individually (see segmented). The segments exemplified how Ms. Jones scaffolded the teaching and learning interactions in the classroom.
Segmented	A well-defined smaller category within all of the data, i.e., an interaction that included vocabulary usage. A smaller category was five to ten sentences, which provided units of meaning (from single words, short sequences of words I jotted down from all the data) in order to attach annotations (codes) to them (Böhm, 1992; Fick, 2002). The notes I jotted down helped me to later determine which segments needed further analysis that would lead to a discussion providing further details on what Ms. Jones' actions were and the student outcome was.
Viewpoint	A deliberate and intentional way of looking at things. In the case of this study, the global and segmented viewpoints of the occurrences in Ms. Jones' classroom.

Definitions of terms that are used throughout the study. These terms were invoked in the analyses of classroom observation.

The data were gathered through classroom observations and I took written notes, videotaped interactions, audiotaped interviews, and collected artifacts (See Figure 3.B), below.

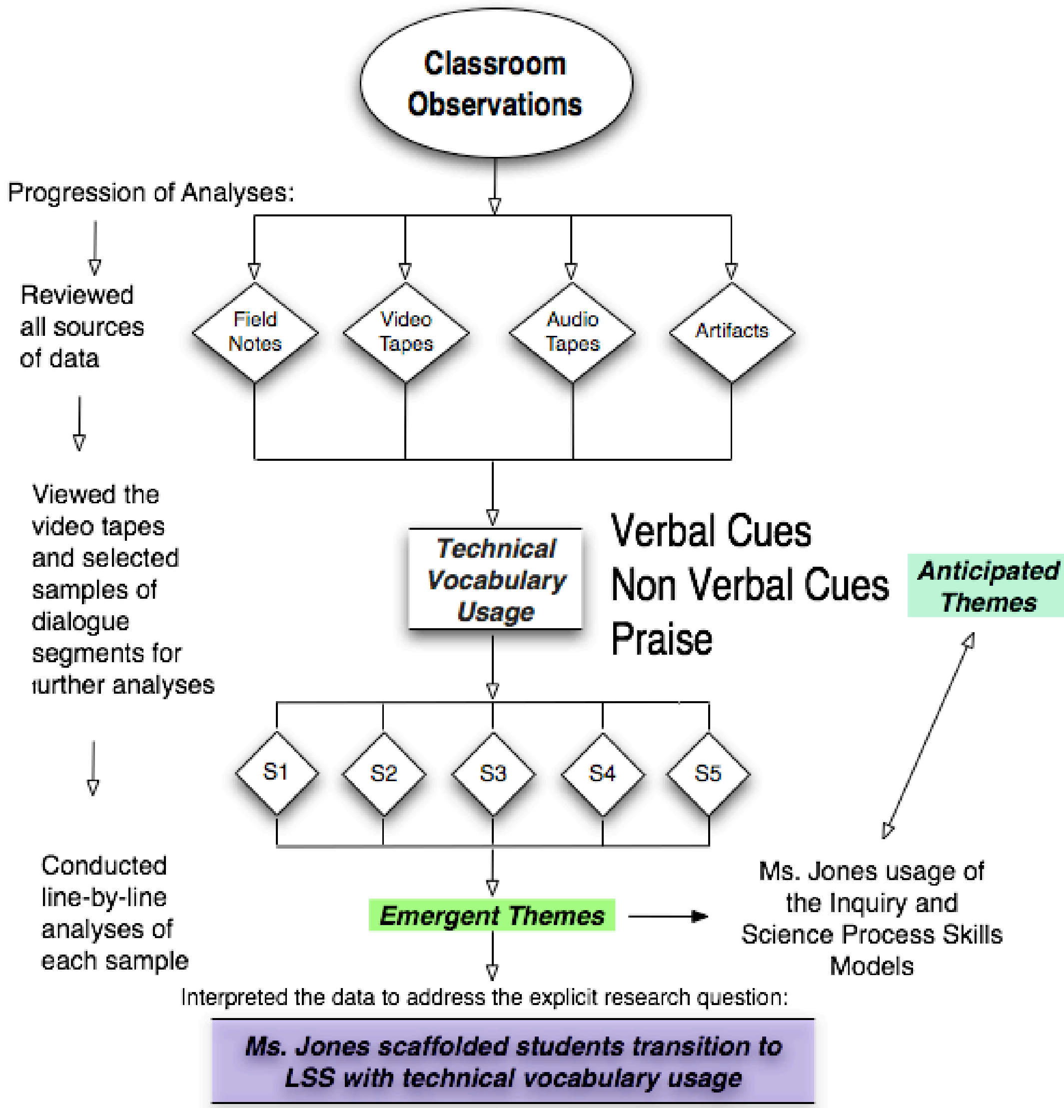


Figure 3.B. This is a diagram of the sequence of analysis of data involved in this complex activity of carrying out a research project. Samples of fieldnotes can be found in Appendix A, transcriptions of videotapes in Appendices D and F and chapter 4, transcription of audiotapes in Appendices B and H, Artifacts in Appendix G.

The data were gathered through classroom observations and I took written notes, videotaped interactions, audiotaped interviews, and collected artifacts. I analyzed the data throughout the study and, in finer detail, at the conclusion of the study period. The multiple sources of data were coded in order to find instances of the anticipated themes (Ms. Jones will use verbal cues, non-verbal cues, and praise to help students transition from “informal Science talk” to “formal Science talk”) and identified emergent themes among the four contexts, above, in response to the research question.

A sample of a selected segment of dialogue, Data Set I[3]:

> T: Let's use an "If … then …" statement
> [Students write in their journals.]
> Property about it – Oil and water: oil floated on the top of water
> Thick – or – Viscous
> Solids
> Using the triple beam balance to mass
> Gravel: 38.6 – 38.8 ➔ 39… = Different mass
> Rice crispy cereal: 13.9
> Mass: gravel > cereal
> Volume: gravel = cereal 15 ml
> Equal volume but different mass
> [Notes for students to write in their journals.]
> What we know about density:
> If the liquid goes to the bottom them it is more dense [denser].
> If we have solids of equal volume and one solid has a greater mass then the solid with the greater mass goes to the bottom and is more dense.
> S: Yellow will have the most mass. Red will have the least mass because yellow always go to the bottom.
> T: He used his data to come up with that answer. Let's come up with an operational definition for [density] tomorrow.

Audio and video transcript analysis and interpretation—The audiotapes were fully transcribed, and these transcripts, together with the field notes, reflective comments, and selected videotaped classroom observations, were transcribed to form the raw data for further analysis. The processes of sampling, data collection and data analysis were continuous and iterative. The videotapes were viewed and re-viewed by the researcher, then the first three hours of data set I were fully transcribed; for the rest of the videotaped data I marked those events that called for more detailed analysis. Those samples of videotaped segments were selected for full transcription. A case study allows the reader to look through the eyes of the researcher; and "assessing the quality of a case study is still the richness of the data presented" (Donmoyer, 1990, p. 196).

I have accounted for the reader to be able to see things in the data that I might not have seen by providing an adequate amount of raw data (Donmoyer, 1990; Lemke, 1990). According to Donmoyer (1990), "there should be sufficient medium-rare data, for example, low-inference descriptions of behavior and excerpts from transcribed

[3]A sample of selected segment of dialogue, Data Set I, from the transcribed field notes in Appendix A.

interviews" (p. 196). Lemke (1990), for example, collected data (consisting of recordings and fieldnotes) from 60 science classes and twenty teachers in one junior and two senior high schools. Only the senior high school data and six 40-minute lessons were selected and presented as part of the appendices in the book. Since I conducted a form of sampling (by transcribing only some segments of dialogue from the videotapes) I countered the limitations of this approach by transcribing my own videotapes and tapes. This allowed me to "get to know their details intimately and when I read the transcripts I could actually rehear voices (qualities and intonations)" (Lemke, 1990, p. 229-230). Lastly, content analyses of supplementary data beyond a search for technical vocabulary usage were conducted. Once the data had been coded, annotated and categorized I began to make interpretations addressing the research question, scaffolding the transition to LSS with technical vocabulary usage.

Quality assurance of data analysis and interpretation—The consistency (reliability) and confirmability (validity) of data analysis and interpretation was assessed using three techniques. First, external validation of all stages of coding and interpretation the semi-structured interview transcripts and partial videotaped lesson observation transcripts were performed by the researcher. The results were compared and there were no significant inconsistencies. Secondly, I discussed the interpretation of the data with an elementary school teacher, a physics and engineering academic, and an assistant Science education professor at a major research university. This process of respondent validation again found no significant criticisms of my interpretation. Thirdly, the results were triangulated with different data sources within the study, with other data collecting methods used in the larger project (including key informant interviews, with the available literature, and with data collected incidentally outside the formal interviews. I gave the most importance to results that were consistent between data sources and with different data collection methods.

Methods of Data Analysis

I generated categories from the anticipated and emergent themes to make sense of the videotapes, fieldnotes and the researcher-teacher interviews using a sociocultural (Vygotsky, 1978) framework to analyze and synthesize the raw data. What emerged was that Ms. Jones used the Inquiry (Data Set 1) and the Science Process Skills (Data Set 2) models to teach Science. In both situations she held fast to her philosophy and purposes for teaching Science.

Lessons were broken down into segments, and the individualized segments were coded. This was an ideal method because I was able to extract categories from the data, not impose them upon the data (Glaser and Strauss, 1967). In the concluding chapter CRP was employed to amalgamate the data findings to discuss, to provide implications for future research, and to conclude the study.

A Sociocultural Perspective of Analysis

A sociocultural perspective of analysis is a good theoretical basis for analyzing this particular classroom. The focus of the study was to observe and report on an understanding of the instructional practices of Ms Jones. I wanted to gain an in-depth understanding of the social interactions between the teacher and the students which occurred during the mediated and/or scaffolded actions as the teacher helped her students transition from "informal Science talk" to "formal Science talk."

Analysis Viewpoints: Materials sampling and sampling within the material

The data were analyzed from a "global viewpoint" followed by a deliberate search, which will transition to a selection of *segmented* moments that would aid in writing up a comprehensive description. A *global viewpoint* is defined as a wall-to-wall picture, painted from all of the data (such as interviews, audiotapes, videotapes, and transcribed fieldnotes) documenting what happened in Ms. Jones' classroom during the study. The global viewpoint is used to illuminate the readers' awareness of the tacit questions that guided the researcher's way to answering the direct research question.

These questions, *tacit* and *explicit*, were components of the continuous dialogues between the teacher/student or student/student, a student clarification of thoughts, or a student description of events. The primary purpose of this formal exposition was to advance a new point of view resulting from a case study of one science teacher specialist's classroom activities posited on answering the following question(s):

Table 3.3: Research Question

Tacit: How did teaching and learning occur in Ms. Jones' milieu?

Global Viewpoint

1. How would you describe the classroom setting?
2. What types of interactions occurred between teacher and individual learners (between teacher and small groups and between teacher and whole class) in this setting?
3. What were Ms. Jones' instructional methods?
    a. How did she scaffold students' learning?
    b. How did she decide what to do (what to try) at each individual moment?
    c. What part did prior knowledge play in her instructional design?
    d. How did she assess student's understanding?
    e. Why did she choose to include vocabulary instruction as part of her instructional design?

Segment Viewpoint

Explicit: How does this teacher scaffold students' transition from "informal Science talk" to "formal Science talk"?

The table was developed to highlight the processes the researcher took in developing the explicit research question.

Having analyzed the data generated pursuant to the anticipated and emergent themes, it was possible to synthesize the findings of this case study with the existing literature, resulting in coherent generalizations that fit within the broader perspective of the reform movement in Science Education.

ESTABLISHING TRUSTWORTHINESS

Though objectivity was is standard that facilitates replication and the possible transfer of findings in subsequent studies, there was a great deal of subjectivity in conducting a qualitative study, as a matter of course. Subjectivity inheres from the fact that the researcher was the research instrument, and this condition dictated the need for establishing trustworthiness. This was accomplished by auditable data collection, which was designed to verify that the researcher's interpretations were credible, transferable, dependable, and confirmable.

Credibility

Credibility was established internally via the researcher's prolonged engagement with the subjects of the study. Such an arrangement ensured that the researcher was not observing an exception to the rule, but a consistent trend exhibited by the subject with regard to her students, who constituted another body of subjects in this study. By collecting multiple forms of data, it was possible to achieve triangulation in data collection, which was an indicator of internal validity. Triangulation is a research design that includes two or more approaches to data collection or analysis, thereby providing internal checks against misinterpretation of a single stream of data.

Transferability

Transferability is the degree to which the findings of the study may be applied to other case studies involving many of the same variables, though the two most significant variables — the researcher's sensibility and the personality of the primary subject — could not readily be duplicated. Transferability was at least a goal towards which the researcher consciously strove. This was evident in the thick description of the research process that allowed a reader to determine whether the results of the study could be transferred to a different setting, thereby indicating the study's degree of external validity.

Dependability

Dependability was established by developing and maintaining meticulous records, providing a body of evidentiary artifacts that readers and subsequent researchers could audit according to their own means and purposes. These records include, but are not necessarily be limited to, logs of communication taking place during the initial phases of the study, throughout the period of observation, compiled in every round of member checking (with Ms. Jones), and verified by the subject's written reaction to the findings of the completed study.

Confirmability

Confirmability audit trail categories are comprised of the following:

i. raw data provided in comprehensive appendices,

ii. data analysis and reduction processes described,
iii. data reconstruction and synthesis, including structuring of categories and themes,
iv. process notes included, and
v. instrument development information included

PURPOSIVE SAMPLE

Domain of study

The study focused on one elementary Science teacher, and one each of her fourth and fifth grade classes. The school is located in the southeast section of a major city in Texas. The social, ethnic, and economic demography of this city changes greatly from north to south and west to east.

The fourth class grade class (the subject of the first set of data collected and the major report in this study) had 18 students including one African-American male, and seven and eleven Hispanic females and males, respectively. The fifth grade class for the subject of the second set of data collected had 19 students, including two African-American males, two white students (one male and one female), and eight and seven Hispanic females and males, respectively. Three teachers were listed as instructors for the classes: one white, one African-American, and one Hispanic. Ms. Jones played two roles in her daily activities: 1) as a model for fourth and fifth grade teachers, and 2) as instructor of the students.

Researcher as Instrument

A case study is a qualitative research method that allows the researcher to determine what approaches to use in selecting single or multiple real-life cases to examine in depth and which instruments and data generating and gathering approaches to use. This study was an opportunity to deepen and broaden my knowledge and understanding of minority issues in a crucial subject area such as Science. There is a surfeit of research and information on failure, and/or inability to be schooled beyond the basics, of black, Hispanic, and Native American subgroups of the school-age population. My research interest — which looks at the roles of culture, language/linguistics, and socialization within these communities when learning a specific domain — began to form after I read the article “How Much Can We Boost I.Q. and Scholastic Achievement?” (Jensen, 1969).

I found that Mr. Jensen’s work led me directly to understand and appreciate Lev Vygotsky’s “Mind in Society: The Development of Higher Psychological Processes” (1978). Children’s learning capacity is affected by experience, such as how the child responds to mediation by a more capable or more experienced other. Interactions between people are cultural by nature, social by action, and we all relate to and with each other differently. Therefore, an evidenced-based example of children of color learning Science through mediated processes of interactions by the teacher (the experienced other) needed to be analyzed.

Academic Experiences

My academic and practical experiences span from engineering to education and accepting responsibility as a teacher of mathematics and Science, respectively. Those experiences as an engineering student molded me for what I would experience in the classroom as the teacher of 30 to 34 students at a time each period. My engineering professors always said that as engineers we are problem solvers. I better understood what they were talking about in my role as a teacher. As an undergraduate student I struggled through some of my classes and was advised on how to study by my mother. Eventually, I gave in and made her way of learning and knowing my plan for success. I tried to apply those same principles to my graduate schooling, but those study strategies fell short and again I began to struggle.

I needed an understanding of self from a perspective of, how do I learn? I did not learn by passively taking in information exactly as the professors transmitted. My accomplishments in school began when I shifted away from trying to learn from structural objectivist approaches to developing constructivist ways of sensemaking and thought. I went home each night and constructed physical models of each problem. This included mostly internal (and some external) dialogues with myself. These experiences in learning are part of my groundwork for teaching and continued academic schooling.

Professional Experiences

I began preparing for this disquisition by teaching mathematics and Science in the New York City public school system. Chief among my responsibilities there was planning instructional strategies appropriate to the needs and strengths of my students. One of my proudest accomplishments was the development of a method of progressive questioning throughout each lesson. As I learned about the needs of my students, I noticed greater and more meaningful communication between us. I feel that it was that level of communication that most helped my students to feel confident about learning Science and mathematics. We had developed a relationship where respect for each other was mutual and communication incorporated elements of teacher and student discourses.

Working with these children I realized that my days were long because preparation time was long. The individualized attention these students needed demonstrated that when students come to the classroom unprepared or underprepared it means that more is required of the teacher to achieve success. More is needed in the sense that the teacher's arsenal of instructional strategies must be bountiful. My attitude and belief in teaching resided in my respect for the profession and for every student I interacted with in the classroom, hallway, lunchroom and schoolyard.

The children I encountered in my first fulltime teaching assignment needed to learn how to socialize in a classroom. They needed to learn about asking or answering questions; they had to learn how to respond within the context of an academic environment, how to make their thoughts public, and how to speak out loud and put their thoughts up for debate or feedback. And especially they had to learn to socialize with me. They brought with them strengths that were conducive to making learning an active process whereby together we were able to construct understandings about teaching and learning that made sense within the context of that classroom milieu.

As part of my administrative and supervisory internship in New York City, I planned and facilitated professional development workshops that informed the implementation of local standards into departments' everyday lesson planning and instruction. I began each workshop by pointing out to teachers that what they were already doing was employing aspects of the standards, and that incorporating one or two more things in specific areas would ensure both compliance with the standards and effective instruction for the students. We discussed how these added measures would greatly benefit the students and eventually bring us all – teachers and students – to a point where student success would predominate. The responses and results of my efforts encouraged me to learn all I could about providing more effective mediation to teachers, especially those teachers working with students labeled as "at-risk." That desire to grow professionally brought me to the University of Texas at Austin, where I have applied the experiences and insights I gained during my tenure in New York to this case study.

SUMMARY

This chapter provided the definition of a case study and the reasons why this research design was the best method for conducting the current qualitative study. Additionally, descriptive details were provided on the sample: teacher, students, school, and district used and the researcher as instrument. Specifically the reader was given insight into the ethnic makeup of the classroom, school, city, and state with regard to students and teachers. Also, the chapter explains why the researcher was a suitable instrument in designing and implementing a case study research design. There are implications for further studies using cultural lenses. A data analysis framework posited on a sociocultural perspective, which has "had an impact on how people think and talk about the education of children from linguistic and cultural minority backgrounds" (McLaughlin & McLeod, 1996, p. 2).

Chapter IV: Results

INTRODUCTION

The purpose of this research was to determine how Ms. Jones scaffolds students' language development by closely examining the instructional strategies used to help her students move from "informal Science talk" to "formal Science talk." My work considered how this teacher approached teaching and learning through the instructional designs she chose and implemented, and explored what Ms. Jones knew and was able to do based on context. For example, I studied the factors she took into consideration when making choices. For this study, "informal Science talk" is defined as a limited domain of discourse with little or no Science vocabulary, while "formal Science talk" is defined as an extended discourse that includes the appropriate use of Science vocabulary.

In Ms. Jones' classroom the goal was teaching for understanding and life long learning, in accordance with the book *How People Learn* (National Research Council 2000), which contains implications for Science teaching. This attitude connoted that Ms. Jones possessed the knowledge and understanding on how students learned and the short- and long-term outcomes of such learning. She has created a classroom milieu that fosters student thinking through participation in high-quality lessons and laboratory experiments. Through an iterative process of questioning and answering students are given the opportunity to think about what they are learning and also self- assess and be able to understand what they do and do not know.

Each classroom session I observed began with 15 minutes of whole group instruction that triggered and accessed students' prior knowledge. Content was taught in context and related to a broader conceptual framework of teaching for understanding via the Inquiry and/or Science Process Skills Models (K. Ostlund, 1992, 1994).

Coding of Observations

I conducted fieldwork with a repertoire of strategies. The strategy I used at each point depended on the research question, feedback from the field, and an understanding of the classroom culture. My lens of analysis was a sociocultural perspective; therefore, the resulting discussions provide details and descriptions about the scaffolding (Ms. Jones' interactions with students) and the milieu that made the interactions in the classroom dynamic.

Data coding was conducted in three phases:

> *Primary:* Reading and rereading my fieldnotes, looking at videos, and simply jotting down notes about Ms. Jones' actions (her interactions with the students). The first line of analysis was viewing the videotapes. Then brief descriptions were written, which were later aligned with the transcribed fieldnotes, along with a description of what was going on in particular tape segments. I also noted the *sin qua non* vocabulary, the type of interaction between teacher and student(s) (e.g. whole class, small group, or individual). I marked events that required more analysis and for the integration of multiple data sources, such as examining related class and district artifacts or teacher interviews. Further analysis included more detailed transcription or repeated viewing of the videotaped event. All audiotaped interviews were transcribed, read and re-read to find information pertinent to answering the implicit research questions, and then the explicit question.
>
> *Secondary:* I decided that the interviews between the teacher and researcher, and the interactions and dialogues between the teacher and her students would be analyzed to answer the implicit and explicit research questions.
>
> *Tertiary:* The finely focused part of the coding aided in developing descriptions about the milieu and Ms. Jones' strategies for teaching vocabulary. It specifically showed how LSS could be developed and how students accorded discourses that were reflective of the language (LSS).

A table serves to introduce the reader to the major terms used to code the data along with samples of the coding scheme [See Table 4.1 in Appendix B]. These themes, verbal cues (VC), non-verbal cues (NVC), and praise (P), are discussed below with supporting evidence.

Ms. Jones' Instructional Approach

The forms of teaching and interactions (between teacher and students) that occurred in Ms. Jones' classroom were located within a Vygotskian praxis of understanding supporting learning and related to other concepts such as scaffolding (Bruner, 1976). These sources of theory do not address the kind of milieu, constructed by Ms. Jones and her students, that was conducive to technical vocabulary learning in Science but they do indicate the aim of strengthening the students' future opportunities for integration in a scientific community. The theoretical implications that were drawn from a case study central to understanding these activities from a sociocultural viewpoint included discussions of the milieu, the instructional flow, laboratory experiences and emergent themes. The emergent themes were Ms. Jones' modes of instruction: the Inquiry and Science Process Skills Models (NSES, and K. Ostlund, 1992, 1994).

THE CO-CONSTRUCTED MILIEU

The Milieu

The classroom was the social environment in which Ms. Jones and her students gathered information and exchanged ideas. The classroom was an instructional milieu conducive to learning the language of school Science (LSS) — an environment co-created by both teacher and students reflective of the sociocultural dimensions of environments of learning. The walls were filled with posters, large chart papers of vocabulary words, and descriptions and discussions from completed work. Ms. Jones regularly gestured or pointed to the walls, and she used verbal and non-verbal cues in conscious, consistent, and continuous ways throughout each lesson.

Laboratory experiments, the pleonastic nature of Science, scientists and scientific discourses are, as in logical reasoning, the processes of using definitions, rules, properties and facts. To validate conditional understanding, language contributions to the milieu came from both teacher and students.

The Instructional Flow

As the researcher I was engaged in finding answers to my research question, which allowed me to focus and to delve deeply into this milieu of teaching and learning with "a high degree of concentration on a limited field of attention."[4] My focus was the evidence of transition in technical vocabulary used by students and scaffolded by Ms. Jones. These elements occurred within larger components that moved along steadily in a stream that I have illustrated in Figure 4.A.

Components (Elements) of the Instructional Flow in this Milieu

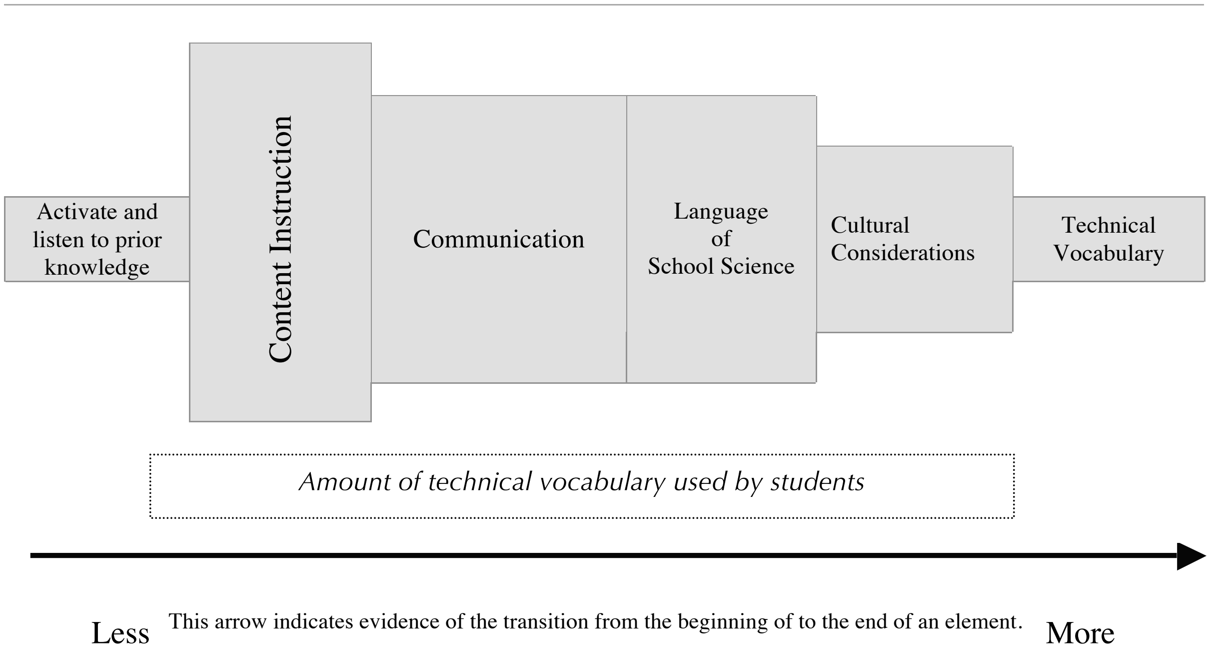


Figure 4.A – This diagram shows the interconnectedness of all the components that make up the design and implementation of instruction. The single arrow above indicates the flow from left to right of the amount of domain-specific vocabulary used by students.

The classroom process was dynamic and multilayered, and I tried to recreate a picture of how words and language "flowed" throughout each class session. I am using the diagram to describe six layers of Ms. Jones' instructional approach that were evident from the data. Content instruction is the major component of the diagram because all

[4] Csikszentmihalyi – (1997) Components of Flow - Not all 8 components are needed for flow to be experienced. The other important condition for getting into flow, is the non-disturbing environment. Every disturbance, such as a phone call, or a new person entering the room, will probably pull you out from flow experience back to the reflecting mode.

other elements flow through instruction. Ms. Jones used the first 10-15 minutes of each classroom session to activate the concept that would be explored that day and to listen to the students' prior knowledge of the topic. Communication was a key feature of the development of the language of school Science (LSS) with technical vocabulary usage. Cultural considerations incorporate and integrate the students' "ways of knowing and learning" that they bring to the classroom, as well as the co-constructed milieu.

In order to accommodate her students' diverse ways of learning, Ms. Jones adapted a variety of teaching strategies in her instructional design: these included direct instruction, hands-on exploration, use of manipulatives and games, practice exercises, analogies, narrative and expository texts, regular reviews of previous work, frequent formative assessments, and instructional materials, including workbooks, textbooks, science laboratory materials, videos, and overhead projections of instructions and student data gathering sheets.

Sample Teaching Strategy I

Direct Instruction

Direct Instruction is a rigorously developed, highly scripted method for teaching that is fast-paced and provides constant interaction between students and the teacher (Engelmann's theory of instruction). Ms. Jones presented clearly defined and prescribed teaching tasks within clear instructions to eliminate misinterpretations. An example, excerpted from a dialogue segment presented below:

> T: You are going to write it on the line. List your manipulated variables on the first line. List your responding variables on the second line. And, list all your control variables on the third line. Are there questions? … Begin, You have two minutes.

Sample Teaching Strategy II

Hands-on Exploration and use of manipulatives, Science lab materials and student data gathering sheets

Students used laboratory apparatus such as beakers, triple beam balance and spring scales, clay to model a ball and boat for buoyancy, etc.

Procedures: [Students helped to write these procedures. Ms. Jones transcribed their words on chart paper.]

1. Mass the object
2. Measure the volume of water and pour it into the big cup
3. Mark the level of the water with the marker (pen)
4. Put the object (material) in the cup of water
5. Mark the level of the displaced water
6. Using a syringe take the displaced water and measure the volume of the displaced water

> Pour the water in the cup then you calibrate it – put a mark on the cup. You are going to see the displace – "new place"

7. Mass the displaced water on a triple beam balance
8. Record all the data
9. Write all results
10. Answer the question whether it sinks or floats.

[A group discussion.]
"It got displaced."
S: What does displace mean?
Same S: Moved to a different section/place.
T: In that cup with water and marbles, what was moving?
S: The water

Sink or Float
Why?

	Mass of Object	Volume of H_2O displaced	Mass of H_2O	Sink or Float
Marbles	230.7 g	44.5 ml	73.7g	Sink

How much? How many ml?
Measure the volume before.
S: Use the graduated cylinder to place the object in and measure the volume at the same time.

T: More matter in a certain volume "What does that remind you of?
S: Density

Sample Teaching Strategy III

Analogy: Narrative and Expository Books/Texts

Ms. Jones used the narrative book *Who Sank the Boat* by Pamela Allen. [See Appendix G] This book was used for the purposes of explanation, clarification, and formative assessment of students' understanding of *buoyancy* [Data Set I]. Also, students were given a one-page handout titled *Experiment with Buoyancy* [See Appendix G]. The students were given some clay to be molded into the shapes of a ball and a rounded cup or boat to determine whether each object sank or floated. Also, students used an expository piece titled, *Experiment with Buoyancy* [See Appendix G]. Another buoyancy experiment, the *pencap submarine,* was assigned as homework.

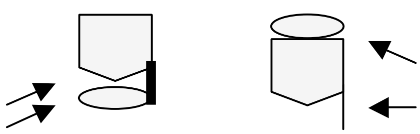
Pencap Submarines

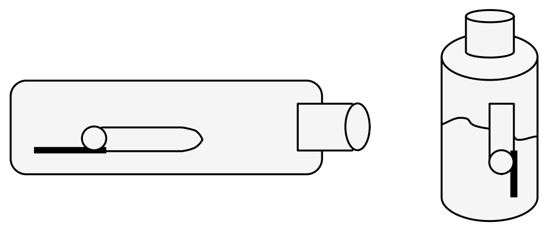
[Below is an at home experiment students built and turned in to Ms. Jones. A submarine in a bottle. Time ran out so students were disappointed about not having the time to share. That student talked one-on-one with Ms. Jones after class about his system.]

S: Bubbles

S: Bubbles in the gas

2 Diagrams: 1) open system 2) closed system





Open system – because water and air get in

Bubbles
Gas
Weight
Shake bottle

Laboratory Experiences

Figure 4.B., below, illustrates how I conceptualized, interpreted, and summarized the transition in language. Students were provided with a range of experiences (hands-on laboratory, discussions, debates, and/or consensus building) in all aspects of their development and growth as scientific thinkers. The aim of this analysis was to explain the possible connection between actions of the teacher and her students, and the cause-and-effect relationship among teacher-student and student-student interactions as the processes of teaching and learning occurred.

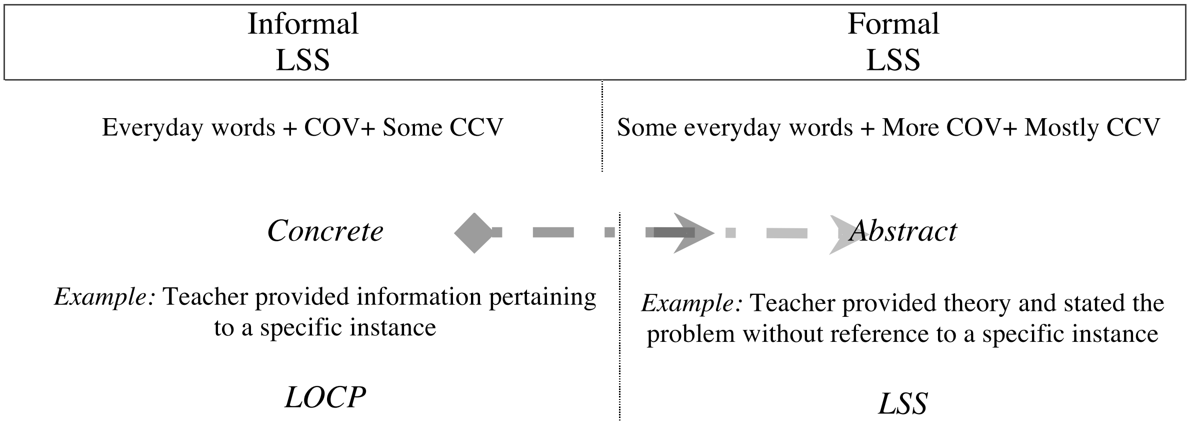


Figure 4.B. This is an illustration of how I interpreted the language transition. The broken arrow indicates that the process was dependent on the individual interactions. The dashed line indicates that the process was dynamic and movement could occur in either direction but movement to the right was the ideal. 1. LOCP = Language of Common Parlance 2. LSS = Language of School Science 3. COV = Content Obligatory Vocabulary 4. CCV = Content Compatible Vocabulary

The key point is that I viewed learning Science as learning a language. The language of school Science (LSS) was imprinted with technical vocabulary (TV) and everyday vocabulary EV]. Ms. Jones' actions in the classroom (scaffolding processes to transition her students' language from informal to formal maturation) were viewed from the perspective of a teacher who had created a classroom milieu rich with the LSS, inclusive of the TV, and integrated into EV.

Ms. Jones' role was to support the process of student acquisition of scientific discourse. She helped the students to transition from using everyday language to using more precise scientific language as they discussed and wrote about Science.

The following is a summary of language learning as observed in this classroom milieu:

- Students were expected to read, write, and speak using the Science terms of each domain (Life and Physical Sciences).
- Students were exposed to technical vocabulary presented orally (by the teacher), in text, in handouts, wall charts and on film or overhead projections.
- Students encountered words they were unlikely to acquire in their everyday lives.

- Students were being prepared for success beyond the four walls of the classroom. Therefore, exposure to and acquisition of the technical vocabulary was viewed as a powerful resource that would help students to access the challenging expository texts they would encounter as they moved forward through their academic studies.

Inquiry and comprehension, which are powerful problem-solving and meaning-making methods, were utilized in this Science classroom. Ms. Jones made use of Science process skills in the classroom, and she modeled the behavior of scientists who as part of their work ask questions and seek answers to those questions. Also, good scientists:

- make and test predictions in order to construct understanding;
- make observations and comparisons;
- draw inferences to, and
- gather information to answer questions and solve problems.

In Ms. Jones' milieu, students were given opportunities to develop comprehension and inquiry skills as they investigated questions in both direct and indirect situations.

EMERGENT THEMES

Inquiry Model

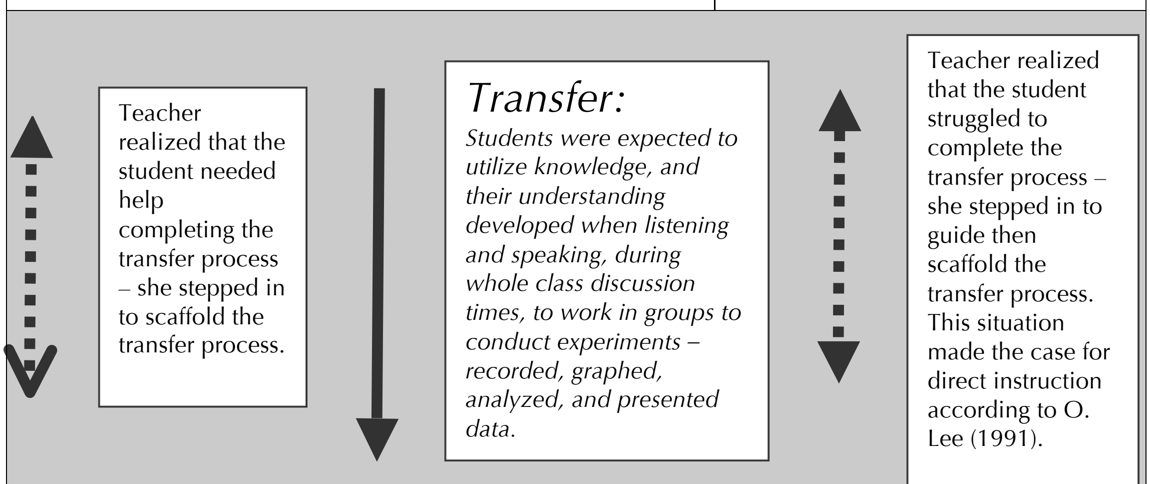
During my pre- and post-observation interviews with Ms. Jones for data set 1, she consistently described her instructional approach as utilizing the *Inquiry Model*. This model encompasses developing critical thinking skills and allowing students to build their own understanding of scientific concepts and principles. Students are scaffolded in the processes of formulating hypotheses, naming and controlling variables, and developing operational definitions.

Ms. Jones has built her teaching around questioning, which I have understood to be a diagnostic tool much like Socratic dialogue (Arons, 1981). This technique develops learners' capacity to clarify issues, to uncover holes in arguments, to correct factual or conceptual errors, and to eventually lead to more thoughtful outcomes.

Table 4.2: Transfer of Knowledge and Understanding

<table>
<tr><td colspan="2">The Quintessential Learning Aspects
Language skills (Listening, Speaking, Reading, and Writing) speed up the learning rate. During the first 15 minutes of every classroom session Ms. Jones and her students were engaged in conversation. This conversation was dominated by questions and answers – students were engaged in listening, speaking, reading and note taking. Ms. Jones used a mixture of everyday language and some technical language (vocabulary) to develop listening comprehension. This was the beginning of language development. By the end of each class, the language of Ms. Jones and her students had developed to where LSS had become an expository dialogue.</td></tr>
<tr><td>Listening: Spoken language comprehension --- Ms. Jones used the LSS and everyday vocabulary and languages to develop her students' listening skills easily and naturally.

Speaking: Students improved their speech by imitating a native speaker. Ms. Jones was the native speaker in this milieu. Whether she was utilizing the Inquiry Model or the Science Process Skills model as her instructional design, she was modeling the way scientists behave.</td><td>Through formative and summative assessments during my own experiences as a Science teacher, I came to understand that students are unable to transfer the knowledge and understanding they develop during speaking into listening, reading and writing.</td></tr>
</table>



<table>
<tr><td>Reading: Students would read text written in the expository scheme of LSS with speed and ease. They linked written language to real-life objects, actions, and ideas.
Writing: Students developed and improved their writing through teacher dictation, charting, projections, and recording data and writing analyses using the generated and gathered data. These students wrote what they heard – syntax and punctuation, so that they could learn by example.</td><td>From my experiences as a Science teacher, I learned that students tend to struggle more with the aspects of reading and writing. Students struggle to transfer their knowledge and understanding that are developed during the listening and speaking segments of learning.</td></tr>
</table>

The solid arrow indicates an ideal process of transfer of knowledge and understanding. The dashed arrow indicates that variables, such as how to begin or what to do first, occurred during transfer (Ms. Jones scaffolded the process).

Ms. Jones helped her students construct knowledge by presenting new information through an iterative process of questioning and answering, which challenged her students' prior experiences. This dynamic interchange was a sound method for approaching new ideas, concepts, knowledge, and language development. Her goals were to nurture inquisitive minds and to help build inquiry skills.

Science Process Skills Model

Ms. Jones modeled each of the Science process skills and the following cognitive strategies: questioning, predicting, clarifying and summarizing [see Table 4.3, below].

Table 4.3. Science Process Skills

<table>
<tr><th>Process Skills: Students Action</th><th>Ms. Jones' interactions with the students</th><th>What occurred during the classroom observations?</th></tr>
<tr><td>Observed: Used their senses</td><td rowspan="8">Modeled and instructed students on how:
- to share information with others in the classroom
- to change a variable and watch what happened
- to use their interactive journals to record data
- to use a beaker or scale to measure
- to use the vocabulary in their oral and written discourses

Specific instances/examples:
- Size of beak, mass of food, size, shape, density of liquid/ Sort your questions by experiment
- Which liquid went to the bottom?
- Which liquid is more dense?
- Which beak/habitat helped you to get more food?
- Why did you get less/more food?
- What would you change? Why?
- What is another word you could use?
- How would you control your variable?</td><td rowspan="8">Students participated in hands-on, minds-on, laboratory experiences to determine:
1) The densities of four liquids, and selected objects (clay ball and boat) to determine which objects sink or float - displacement
2) Used different tools, representing beaks (tweezers, tongs, tongue depressors, pliers, and wrenches) to determine which will help them gather food (rice, gummy worms, nuts) from different habitats (sandy beach, log, swamp).</td></tr>
<tr><td>Experimented: Changed something and watched what happened</td></tr>
<tr><td>Collaborated: Worked in whole class, pairs, and groups to discuss or conduct experiments</td></tr>
<tr><td>Recorded: Used their interactive journals to record data and write down instructions.</td></tr>
<tr><td>Measured: Used instruments such as rulers, triple beam balance, beakers and spring scale.</td></tr>
<tr><td>Sorted/Classified: Used given and observed information to determine next action and sorted and classified given and gathered data to form conclusions or future steps</td></tr>
<tr><td>Compared: Questioned: Which liquid was more dense? Which one was biggest? Which went the farthest?</td></tr>
<tr><td>Analyzed and Shared: Explained: Why did this happen? Told others what they did and what happened.</td></tr>
</table>

Students are expected to comport themselves as scientists:
Articulate students are able to: -

- Communicate
- Label
- Diagram/Graph
- Record Data
- Question
- Predict
- Clarify
- Summarize
- Compare/Contrast,
- Make public/Debate
- Defend
- Inquire

"Habits of Mind"

Adapted from K. Ostlund's (1992 and 1994) work on the Science Process Skills. The University of Texas at Austin

Ms. Jones aim was to actively engage the students with the Science they were learning and thus enable them to reach a deeper understanding of the content, to become more interested in, and to develop positive attitudes toward Science.

The Vocabulary

In this section, I present the findings from segment viewpoints where elements of the dialogues were deconstructed and analyzed through a sociocultural lens to produce discussions. Ms. Jones scaffolded, built and co-constructed with students to develop responses, which included explanations, discussions, analyses, and questions. There was evidence that the language of school Science was spoken.

CODING OF OBSERVATIONS

Coding of the data for this section was conducted in three phases:

> *Primary:* Reading and rereading my fieldnotes, looking at videos, and simply jotting down any vocabulary word that related to the content — such as density, volume, matter, habitat, variables, manipulated, control, and responding. *Secondary:* Deciding that only interactions and dialogues between teacher and students would be analyzed to answer the implicit and explicit research questions. *Tertiary:* The finely focused part of the coding that helped me to separate the vocabulary in a way that specifically showed how LSS could be developed and how students' discourses could be transitioned. Table 4.4, below, summarizes the findings.

Table 4.4: Definition of terms used in Analyses

<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>Content Obligatory Vocabulary (COV)</td><td>COV was defined as word usage that was customary or routine—that is, expected of everyone or on any occasion (Common Parlance = CP)—but within the context of speaking the language of school science COV becomes a part of CCV.</td></tr>
<tr><td>Content Compatible Vocabulary (CCV)</td><td>CCV was defined as word usage that was consistent with the domain or Science.</td></tr>
<tr><td colspan="2">Limited Domain of Discourse = Informal
Discourse that utilized little or no technical vocabulary. This form of expression is not supported on standardized examinations, when each student is expected to perform proficiently by reading and answering questions that are written in an expository format.
The teacher must help in the transition to formal discourse through the process of integrating content obligatory vocabulary (COV) and content compatible vocabulary (CCV) when writing or speaking the language of Science, because students are expected to listen to teacher language or visual and auditory media and to read the language of Science, which is expository by nature.</td></tr>
<tr><td colspan="2">Extended Discourse = Formal
Discourse that includes the appropriate use of Science (technical) vocabulary.</td></tr>
</table>

Definitions of terms that aided in providing descriptions of the instances that were selected for in depth analysis.

Technical Vocabulary in the Science Classroom

According to Delpit (2001), "Although their [educators] job is to teach the [vocabulary rich] literate discourse styles to all their students, they question whether that is a task they should actually accomplish for poor students and students of color." The language of school Science could be spoken as a Limited Domain Discourse or as an Extended Domain Discourse.

Delpit also contends that students can learn and "teachers must acknowledge and validate students' home language without using it to limit students' potential." At least, Delpit argues, teachers must teach "superficial features of the dominant discourse" and, to the fullest extent possible, the "more subtle aspects." (Delpit, 1992). For this study, the superficial features were everyday words. In an ideal learning experience, teachers and students use COV, CCV, and the "more subtle aspects" in the extended discourse. The sample below introduces evidence to show the beginning of what can be developed using Ms. Jones' instructional design.

A Sample Brainstorming Session[5]

Scenario 1: [The students were seated on the floor in front of Ms. Jones. She was seated on a stool in front of an easel with large chart paper and a marker. She recorded student responses on the paper.]

T: Let us brainstorm: Why do objects sink or float? You will use your data to help you explain and give examples.

[They revisited the vocabulary that was used.]

Vocabulary

sink	gravity	clay ball
float	weight	clay boat
buoyancy	mass	spring scale (weight of displaced water)
buoyant	Archimedes	water
displace	experiment	bowl
capacity	submarine	beaker
material	shape	syringe
conclusion	gas	container
hypothesis	matter	

Scenario 2: [Students went to their tables in groups but worked individually to write in their interactive journals using the data and the vocabulary from the brainstorming activity.]

[5] Sample 1.1. T = teacher, R = researcher notes, and S = student.

Scenario 3: Sharing [Students shared their written work orally. They were instructed by Ms. Jones to use examples of other students models to write their own.]
T to S: I liked the way you started that sentence.
[Ms. Jones introduced the words "physical change" to student explanations.]
T: The change in shape determined whether or not the ball or boat sank or floated. The change in the shape and area of the object with the same matter/weight is the same.
T: Is the displaced water the same?
S: It is 5 extra grams in the water.

In this brainstorming activity, sample 1.1, Ms. Jones set the stage beginning with an oral recall of the vocabulary words that were used throughout the prior sessions. Then students were expected to use those words in their written and oral discourses.

A Sample Dialogue[6]

Which items had more displaced water? The sinking items or floating items? The eraser displaced 20 grams (variable) of H_2O (water). Did the eraser sink or float? The eraser sank to the bottom. To the bottom was our definition of sink. [Students are always being instructed to look at their data recorded in their interactive journals. The class dialogue developed along these lines:] True Sentence: The objects that have less mass are the ones that are more likely to float. I disagree because a washer sinks. Objects with more mass tend to sink. Space influences the sinking or floating. In water you can pick up almost anything. Change the shape of some object.

As Khisty and Chval note, Ms. Jones and the students provided language to the milieu — "an environment was created that was filled with words – rich words – that students appropriated as their own, used as tools for their thinking, and used as tools to communicate their thinking" (Khisty & Chval, 2002, p. 154).

Scaffolded interactions integrate the social and cultural dimensions of learning. A larger sample of a coded dialogue between Ms. Jones and her students is presented in Appendix D. The following discussion explains how Ms. Jones helped her students to develop school Science discourse by integrating the students' cultural productions.

[6] Sample 1.2.This dialogue occurred on the tenth day of data set one. It was taken verbatim from my fieldnotes journal. It was written in the journal without indications as whether the teacher or the students were speaking. The words in the square brackets are those of the researcher.

Anticipated Themes

Broadly defined themes (verbal cues, non-verbal cues and praise) directed the path of this study. Ms. Jones used these strategies to transition student discourses from informal Science talk to formal Science talk. Within the verbal and non-verbal cues and the praise that Ms. Jones used I found evidence that students incorporated the technical vocabulary of the domains of Physical Science and life Science. According to Lemke (1990), the teacher and students play a dialogue game through an organizational pattern which provides the structure within which, they talk Science. Ms. Jones' teaching included an activity structure of questions, bids and nominations, and answers and evaluations.

Data Set I:

Ms. Jones' Science class emphasized laboratory exercises to give students hands-on experiences and to provide support and reinforcement of the concepts being studied. The language of school Science (LSS) was developed through Ms. Jones overtly using verbal cues as part of her instructional approach. According to scientifically based reading research (SBRR), the Quintessential Learning aspects for developing language skills include listening, speaking, reading and writing. According to Vygotsky (1978), a fundamental means by which we develop our intelligence is internalization. Thus, Vygotsky advocates that we incorporate into ourselves what we appropriate from our milieux.

The three tables below were developed to show evidence of the frequency with which the anticipated themes, verbal cues, non-verbal cues and praise were used as part of the teaching and learning process. The evidence showed that verbal cues were used more often in this classroom milieu than non-verbal cues and praise. Ms. Jones. as the scaffolder, responded to her students' questions and responses, navigating from lower to higher levels (Blooms Taxonomy – See Appendix E) to promote the students' language development and thinking skills.

Selected Segment of Dialogue: This analysis was based on the transcript of the first two lessons observed. Each lesson was 45 minutes long. The transcript consisted of 229 lines in 10- point font. See tables (4.VC-1, 2, 4.N-VC, and 4.Pr) below for the frequency with which Ms. Jones of used each cue.

Table 4.VC-1: Verbal Cues

Instructional Strategy	Freq	Some Samples from the Transcript
1. Open-ended questioning:	~~////~~ ~~////~~ ~~////~~ ////	1. Who can review? What are we trying to find and why? Who can help me with the challenge? 2. She is using vocabulary we've used before… and so she is using the word *mixture*. **Question:** Anyone wants to comment on that? 3. Student: Something might be dissolved. Ms. Jones: Something might be dissolved in the. . . .What is the evidence of that? How do you know something is dissolved in it? How do you know there might be sugar or other things dissolved in it? 4. What does that tell you about density?
2. Modeling the Language: Ms. Jones used the vocabulary in the context of her "talk."	//	1. All of the liquids that we are using are transparent. 2. What does that tell you about the density?
3. Introduces the vocabulary: Ms. Jones introduced the vocabulary and asked students to say what they know about the word.	///	1. All of the liquids that we are using are *transparent*. 2. Student: The thickness. Ms. Jones: Maybe the thickness. Another word for thickness, *viscosity*. Have you heard the word?
4. Student introduces or uses the vocabulary and Ms. Jones highlights this event to the entire class.	//	1. Student (F): We are trying to find out if the four mixtures can make layers. Ms. Jones: She is using vocabulary we've used before… and so she is using the word *mixtur*e. 2. Student: Something might be *dissolved*. Ms. Jones: …something might be dissolved in them. [Then she asks three questions about the possibility that something was dissolved in the liquid.]
5. Provides explanations or elaborates on a student response [In some instances, Ms. Jones used questioning… open- and closed-ended questions in her elaborations]	~~////~~ ~~////~~ ~~////~~ ///	1. Which items had more displaced water? The sinking items or floating items? The eraser displaced 20 grams (variable) of H_2O (water). Did the eraser sink or float? 2. Make some decisions. Now that you know a little information about liquids. S3 and his partners were already discovering…about what order you're going to put your liquid, then what do we do third? S17, what are we gonna do next?

A frequency table to show how many times Ms. Jones used verbal cues. See Appendix D for the transcript used for this data.

Table 4.N-VC: Non-verbal Cues

Instructional Strategy	Freq	Some Samples from the Transcript
1. Shakes head	/	While watching the videotapes, I observed moments when Ms. Jones used non-verbal cues. These examples came in the forms of: 1. Ms. Jones shaking her head up and down in affirmation to a student. 2. Ms. Jones making a face. [In this particular case, Ms. Jones made a face after introducing the term *viscosity*. Then she continued by noting that this was a big word.] 3. Ms. Jones points to a student for an answer to a question.
2. Hand gesture	/	
3. Makes a face.	/	
4. Points to the wall or to a student for an answer.	///	

A frequency table to show how many times Ms. Jones used non-verbal cues. See Appendix D for the transcript used for this data.

Table 4.Pr: Praise

Instructional Strategy	Freq	Some Samples from the Transcript
Compliments student (s)	////	1. You have great questions and you have comments and great thinking skills so that's what we're working on. [Ms. Jones made these statements to all the students. The students were asking questions about me, the camera, and the microphone] 2. She is using vocabulary we've used before… and so she is using the word *mixture*. 3. I love your comments. 4. I like how you are using your notes.

A frequency table to show how many times Ms. Jones used praise. See Appendix D for the transcript used for this data.

Table 4.VC-2: A comparison table

Anticipated Themes	Verbal Cues	Non-verbal Cues	Praise
Frequency	**44**	**6**	**4**
In all, there were a total of 54 instances of verbal cues, nonverbal cues, and praise in the 90 minutes of class time. 4 of 54 = 7.4% 6 of 54 = 11.1% 44 of 54 = 81.5 %			

This table was created to illustrate the major differences in Ms. Jones' use of verbal cues compared to her use of on-verbal cues and praise.

Data Set II

The sample dialogue segment below was coded to provide descriptions [See Appendix F for samples of coding]. In this sample, in lines 0 through 6, Ms. Jones populated her instructions with the following CCV — manipulated variables, responding variables, and control variables. These words were printed on a handout students were expected to complete. But before one group could begin recording their information they needed help with their team question. The team question would help them determine whether the team was going to conduct an experiment or a systematic observation.

In line 8, a student (S7) from the group presented the group question orally: "How much will we actually pick up if we had different beaks? Ms. Jones' first question to the group (in line 9) was "What is the key word in your question?" She followed through with many other questions, and called for student elaboration through nomination (each member of the group was given a chance to speak). Later on, Ms. Jones reached out to the entire class (beginning on line 71), and then she called on a student by name (line 88) for help with the dilemma. These steps were tools to scaffold the process of learning. All three students in the group were viable partners in the interactions.

Sample Dialogue[7]

T: You are going to write it on the line. List your manipulated variables on the first line. List your responding variables on the second line. And, list all your control variables on the third line. Are there questions? … Begin, You have two minutes.
T→S0: The information is here. List all of those where it says control variables. List any manipulated variable…you have none. List your responding variables.
[Ms. Jones was pointing (running her finger over the words on the paper) to the students' paper.]
[Student in the background says, Ms. Jones. She walks over to that student's group.]
S7: …how much will we actually pick up if we had different beaks?
T: What is the key word there in your question?
S7: Different
T: Different beaks…how much rice will this beak collect? Tell me if I am wrong? How much rice will the different beak collect?
S2: We are just trying to see if…
T: What beak are you going to use? Name the beak.
S7: Tweezers.
T: So, you want to know how much food the tweezers will pick up? Is that what you want to know?
S7: That's all we want to know.
T: So write it that way. Write your question that way. How much food will the

[7] Sample Dialogue 1.3. I used the numbers 1 – 20 to identify students. S0 = unidentified student. I could not decipher the voice or remember who was sitting in that position. That student was off camera.

tweezers pick up? … in what habitat?

S0: Not just the tweezers.

T: Oh?

S6: We are not comparing we just want to know how much food we will pick.

T: … with my beak … maybe we should use the word *my* and take the word *different* out of the sentence because that is what is confusing me. So let's use the words *my beak* instead of *different beak*. So, start the sentence again.

T, S2, S6, S7: How much …

S2, S6, S7: … rice will we pick up if we hand my beak?

T: Our own beak, right?

T → S7: You want to know how much rice your beak collects? I understand that …that's all you want to know? Is that right?

S7: Mmm …

T → S2: You want to know how much rice your beak collects?

T2: Mmm

T → S6: You want to know how much rice your beak collects? Yes, …

S6: Yes

S7: I want to know how many [pieces of food my beak collects].

T: Are you comparing your beak to her beak?

S7: No, we just want to use each beak.

T: If you want to know how much each of the beaks collects. Isn't that comparing?

S7: No …

S2: We just want to use each beak. We just want to use each beak one time so we can see how it is.

T: I understand that … if you change a variable … If you have different variables (different beaks) … it is an experiment. You are manipulating that variable.

S7: We are not comparing.

T: Actually, you are comparing [Also, … because have a different beak … down] and you are collecting … you are not using the same beak. *If she were using tweezers, and you were using tweezers, then I would say yeah* … that's a systematic observation.

S7: But, we don't have the same one [beak] … we have different ones [beaks]…

T: Why not? Why not? I can get tweezers from all the groups. I could not give you all tweezers? Could I not do that?

S7: No, …

T: Why not? I can get more tweezers. I can go to the store and buy more tweezers. [Ms. Jones was smiling and questioning these students (S2, S6, and S7) about gathering up all the tweezers, simply getting each of them tweezers.] Do you see what I am saying?

S2: We are just trying to see…

T: So this is what I need you to do. Rewrite your question so it tells me that you are not comparing. Rewrite your question so it makes sense to others.

S7: How will we write it?

S6: Like this, how much rice would we pick up if we had our own beak?

T: Okay, what beak do you want to use?

S6: Wrench

T: Wrench … So, what is the question? What's the question? What's the team question? What's the team question?

S6: How much rice would we pick up if we had our own beaks? We are not comparing. We are just trying to …

S7: We are trying to see how much we can pick up [with our own beak].

T: Let’s ask the group [Ms. Jones was referring to the entire class.]. Clap once [clap], clap twice [clap, clap] …We have a dilemma. We have a problem here. They are going to talk to you about [A student was talking in the background. Ms. Jones pauses and looks around. This was a long pause. I did not measure the time.] They are going to talk to you about a question or a concern they are running into. Tell me your opinion. Listen to the question. Talk real loud.

S6: How much rice would we pick up if we had our own beaks?

T: Tell them what beak you want to use … you …

S6: I want to use the wrench.

T: Wrench

S7: Tweezers

T: Tweezers, the next person

S2: I don’t know.

T: Let’s say tongue depressor. Alright. So, they are using 3 different beaks, different …. All of them are using different beaks. So now, the problem is this. They don’t know if this question is …

S7, S2: … systematic observation or experiment

T: I was kind of confused too. So, how can we help them? S3 tell us your thoughts.

The highlighted portions of the dialogue are examples of how Ms. Jones used questions, possible scenarios, and made suggestions to prompt students to be more complete in their talk and to explain the meanings behind their thoughts. Ms. Jones and the students used specific vocabulary throughout this segment of dialogue. They used the name of each tool (tweezers, wrench and tongue depressor) used as a beak and the name of the food (rice). These names have become part of the domain (specific) compatible list of vocabulary words (CCV)—they made up the language Ms. Jones and her students were speaking. Ms. Jones consistently modeled how these terms were to be used.

An example from another session:

> I am modeling what I want to do.
> I am going to model for you:
>
> - I am going to keep my <u>habitat</u> the same [her habitat was a log]
> - I am going to keep my <u>food</u> the same.
> - I am going to keep the <u>size</u> of my holes the same.
> - I am going to keep my <u>time</u> the same.
> - I am going to keep my <u>behavior</u> the same.
> - I am going to <u>change</u> my beak.
> - I am going to measure the <u>amount of food</u>. That is my <u>responding variable</u>.

The 90-line dialogue provided above was transcribed verbatim from Data Set 2 (Appendix F). The language of school Science in Ms. Jones' classroom was developed through an iterative process of questioning and answering that was necessary for the development of a deep level of cognitive academic language proficiency rich in the vocabulary of the language. Table 4.5 (Appendix E) was developed to place into context the language and vocabulary processes as interpreted through the cognitive levels of Blooms Taxonomy, knowledge, comprehension, application, analysis, synthesis, and evaluation [Also, see Appendix E for sample questions from the classroom].

Table (4.VC-3), below, was created to provide more evidence that the overarching theme in Ms. Jones milieu was talk, which was generated through an overt use of verbal cues:

Table 4. VC-3: Verbal Cues In Action

			Tally	Total
Verbal Cues	**Ms. Jones**	Open-ended questioning (Lines: 2, 9, 11, 12, 12, 14, 16, 17, 19-20, 20, 29, 30, 38, 62, 64, 66, 66, 66, 67, 86, l-m, m, p, x-y)	### ### ### ### ### /	26
		Getting students to explain/defend through questioning (Lines: 29, 33, 35, 40, f-g, i-j, l-m, and x-y)	### ///	8
		Explaining (Lines: 0, 1, 2, 19-20, 24-26, 47-49)	### //	7
		Teacher introduces the vocabulary (Lines: 0, 1, 2, u, u)	### /	6
		Teacher uses the vocabulary (Lines: 3, 4, 4, 20, 37, 44, 44, 45, 45, 45, 45, 77, 88, n, v, v, v, u, u, x, and y)	### ### ### ### ///	23
	Students	Students defending their position (Lines: 18, 21, 23, 37, 39, 42, 42, 46, 50, 53, 57, 66, 67, 68, o, q, r, s, v, and w)	### ### ### ###	20
		Students use the vocabulary (Lines: 8, 39, 42, 42, 45, 49, 50, 63, 64, 70, 77, 87, 87, a, b, b, c, c, h, k, q, and v)	### ### ### ### ///	23
		Student providing an explanation (Lines: a-d)	//	2
			Number of instances recorded	115

In this particular scenario from Data Set II, I was able to record samples of Ms. Jones' and the students' use of Verbal Cues. The lines were 0 – 89 and a – z below.

Language of School Science Maturation

Ms. Jones scaffolded the transition from *informal* to *formal* Science talk by developing language and — along with her students — building a classroom milieu rich with talk, debate, conversation, questions, answers and discussions. Initially this language-rich milieu was filled with "everyday" words for predictions, hypotheses, and observations. Throughout the students' growth as scientific thinkers—that is, as they learned *how* to investigate—Ms. Jones introduced and integrated the technical vocabulary specific to the *process*. As students *applied* their knowledge of the scientific process to investigations of scientific phenomena, Ms. Jones explicitly integrated the technical vocabulary relevant to the students' *observations*. It was through this deliberate application of scientific thinking to examinations of everyday phenomena that students learned about the scientific concepts and scientific vocabulary that made up the world around them.

Ms. Jones' instructional choices were conscious and intentional because she believed that all students could and must become independent and self-regulated learners. She understood the needs of her students and provided carefully scaffolded support on a group and individual basis.

Tables 4.5 and 4.6 (which can be found in their entirety in Appendix B) were adapted from all the data to interpret Ms. Jones' actions and decision-making strategies. To summarize the data, I used the mathematical term *conditional statements*, which possessed *if-then statements* when broken into parts. What followed *if* was the hypothesis (the term representing the action) and that which followed *then* was the conclusion (a description of what Ms. Jones knew or did).

The 26 lines of dialogue below show how the discourse patterns of students developed and how the amount of intervention by Ms. Jones decreased. The two segments of dialogue, lines 0-89 and *a-z*, illuminate a transition in pattern of academic discourse/Discourse (Gee, 2004). The dialogue progressed gradually from a simple to a more complex form that included the appropriate use of school Science (technical) vocabulary, COV and CCV. That is the "academic discourse" that Ms. Jones used as part of her talk to extend her students' thinking and to model scientific discourse.

a S3: I think it's a systematic observation because they never said anything about
b comparing to each others' beak. An experiment will be like getting … say like how
c much food each of them must get and they compare it like on a graph or something
d like that.

[Ms. Jones is in the background saying … mmm, … mmm]
T: Read your question again. Tell me what words in their question makes you think that. Read the question one more time.
S6: How much rice would we pick up if we had our own beak?
T: You changed the word from "different" to "own?" Right? Here is what they first said. Read it the first way.
S6: How much rice would we pick up if we had different beaks?
T: If we had different beaks? That's the way they said it the first time. What do you guys think about the way they wrote it the first time? Does it sound like they are comparing?
S7: I don't …
T: You don't! Why?
S7: Different doesn't mean comparing.
S2: Now it sounds like comparing. Different just means something else … it's not the same.
T: I have another group that says – How much food can we collect out of different habitats? They used the word different. And, they said they were comparing habitats.
S6: They have an experiment.
S2: That's because of the way they put the question.
T: Oh! If the way you write the question makes it sound like it an experiment. Can you change the way you write the question to make it a systematic observation?
S2: [Shakes head up and down]

Ms. Jones assessed her students' understanding (comprehension) of the scientific terms or the concepts through, as she explained to me, "questioning, which provided information regarding their understanding, reviewing students written journals or response pages, listening to student/student interactions, assessing the way in which they used the scientific terms/concepts, and listening during lesson debrief" (Ms. Jones).

Ms. Jones used the information (formative and summative assessment data) she gathered during each lesson in subsequent lesson planning. As she explained, "The assessments, whether they are anecdotal or observational assessments or other forms of assessment, drove instruction. Knowing where student understanding was helped me to make instructional decisions" (Ms. Jones).

CONCLUDING DISCUSSION: A RENDERING OF THE ASSERTIONS

In Ms. Jones' classroom the goal is teaching for understanding and lifelong learning. The vignette below suggests that Ms. Jones knows the content, the learner, and how to teach content to the learner, because her teaching proceeds from the presumption that all students are capable of learning.

Vignette

Ms. Jones is a Science teacher specialist at an elementary school in the east side of a major city in Texas. She teaches Science to students from first through fifth grades, and also models how to teach the lessons for other classroom teachers. Ms. Drinks was a novice teacher for whom Ms. Jones provided modeling (professional development) throughout her first year as a fourth grade teacher. The following is an excerpt from an interview conducted with Ms. Drinks:

> R: What is your philosophy of teaching?
>
> Ms. Drinks: I think that you have to meet the students where they are but not lower your expectations for them, which I just think with our students, it's so easy to say "well, I'm not going to ask them to do it because they haven't had it or they don't understand. [In an answer to a follow-up question, Ms Drinks described "our students" as "low socioeconomic [SES] and eastside children."] They're not going to get help at home or they're not going to do it because I just think in the real world they don't lower the bar for you.

Ms. Drinks' teaching philosophy emphasized the need to offer more instruction—scaffolding, vocabulary, language, hands-on exploration—to students labeled "at risk." In the case of this study, Ms. Drinks' response provided insight into how she interpreted what "outsiders" had to say about students who are not living the lifestyle of the status quo (socially, politically, linguistically, culturally and educationally). Her view was that students who lived on the eastside of this major city were typically low SES, and that some teachers considered them to be burden to because they are unprepared or underprepared. This paralleled the views of Delpit (1986, 1988) and Warren and Rosebery (1993) that these students in particular need of explicit teaching in how to value, talk, write, and interact to catch up with the better-prepared students. By watching Ms. Jones teach, Ms. Drinks learned to approach each student with respect for who each student is now and for what each of them can become in the future. In the following excerpt from the pre-observation interview, Ms. Jones describes what Science is:

> L: What is the most important aspect of teaching Science that you want those teachers to take away?
>
> P: That Science is multifaceted. Science is not just getting out the equipment and doing some fun activity. Science is doing a Science inquiry lesson that questioning is important and trying to get to the [meat] of the lesson, understanding the content. Science also includes vocabulary and language and language needs to be built through a variety of ways, meaning hands on. Some students learn by doing a hands-on activity and learn language by doing and seeing a particular activity or a particular outcome of an investigation. Some students learn by seeing visuals, some students learn by reading text, expository text or even narrative text, has a lot of Science in narrative text. So Science is multifaceted and questioning throughout. Inquiry-based Science is not just doing the fun hands on activity, it's multifaceted.
>
> L: What is the most important aspect of learning Science that you want your students to take away?
>
> P: I want them to understand how to do Science. I don't just want them to understand the content, because Science facts are, sometimes facts change over time. I was talking to the librarian this morning about that, she's weeding out library books, and some of the library books that are older have facts that are no longer true because we've found evidence of new discoveries in Science. So, I don't want them necessarily just to memorize facts but I want them to understand how to do Science; to pose a question, to go through the process of investigating, hypothesizing, setting up an investigation and seeing, collecting data and coming to a conclusion about what the outcome of that question is. Along the way they learn language. Along the way they learn facts. Along the way they learn content. But I want them to be able to think, ask questions and think for themselves.

Ms. Jones talked—populated the environment with scientific words (Khisty & Chval, 2001)—modeled the discourse/Discourse (Gee, 2004) of a Science classroom; and most importantly, she acknowledged that all students can and should learn Science content along with its requisite language and vocabulary. The processes and outcomes of the interactions in this classroom were presented in verbal forms through discourse patterns that emphasized Vygotsky's (1978) notion of participants in a dialogue.

Ms. Jones used scaffolding as a way to facilitate the students' transition from "informal Science talk" to "formal Science talk." She "clearly delineated what achievement means in the context of her classroom" (Ladson-Billings, 2001, p. 74). She consistently affirmed the value of her students' questions, responses, and the role each student played as a viable member of the conversations. With her support the students used the terms of the language of school Science, they increased the length of their responses to questions, and they defended their positions (See sample dialogue lines *a-w*, above). Thus, the quality of talk in the classroom matured.

Ms. Jones promoted and encouraged growth in her students' Science talk through her willingness to pass the "baton." For this study, the baton is a metaphor for the "language of school Science" and the overtly used verbal cues, which initiated the development of language that was a part of the discourse/Discourse (Gee, 2004). The following excerpts, taken from different points in the sample dialogue used above, are examples of the "Science talk" used by Ms. Jones and a student.

> T: Actually, you are comparing [Also, … because have a different beak … down] and you are collecting … you are not using the same beak. *If she were using tweezers, and you were using tweezers, then I would say yeah …* that's a systematic observation.
>
> S3: I think it's a systematic observation because they never said anything about comparing to each other's beak. An experiment will be like getting … say like how much food each of them must get and they compare it like on a graph or something like that.

In this vignette, we can see Ms. Jones' view of Science and how it should be taught. I summarized her actions in the classroom, focusing on how she interacted with the students. The explicit research question was: How does this teacher scaffold students' transition from informal Science talk to formal Science talk?

But implicit questions also emerged: How did she scaffold this transition? What specific instructional strategies led to "formal Science talk"? Was one strategy more important that the others? Table 4.7 below presents the amount of scaffolding Ms. Jones provided as needed.

Table 4.7: Scaffolding that Assisted Students in their Transition

Amount of Scaffolding

Most 10 — 8 — 6 — 4 — 2 *Less*

More → Less

Verbal Cues	Non-verbal Cues	Praise
There was more evidence of Ms. Jones' use of verbal cues to promote language development with the requisite technical vocabulary usage. Her instructional approach relied heavily on questioning, which I interpreted as "mining" for information (See table 5.3, in Chapter V).	Though Ms. Jones used non-verbal cues, such as hand gestures (pointing), shaking of the head up and down (in agreement), tentative looks on her face as she tried to understand	There were many instances when Ms. Jones used praise. But, it was not the focal point of the analyses. The milieu that was co-constructed by Ms. Jones and her students regarded each person in the room as a viable partner in the teaching and learning process.

Verbal and non-verbal cues and praise played significant roles in the teaching and learning process. Praise is at the lower end of the spectrum of cues, but that does not nullify the part it played in the learning transition. Each student in the classroom was acknowledged to be a viable member of the learning group. Ms. Jones explicitly and openly respected all of her students, and the part they played was a fixed and integral part of the daily process of teaching and learning. Ms. Jones' use of verbal cues became the focal point of the study, because talk was the medium of instruction.

Scaffolding that supported students as they transitions from 'informal Science talk" to "formal Science talk."

A dashed two-headed arrow was used to signify that scaffolding is not a fluid linear process but is dynamic—changes in amount can occur at any moment (from most to less but never none). As Vygotsky writes, "The teacher must orient [her] work not on yesterday's development in the child but on tomorrow's. Only then will [she] be able to use instruction to bring out those processes of development that lie in the zone of proximal development" (Vygotsky, 1987, p. 211).

The broadly-defined anticipated themes that guided this study were the verbal- and non-verbal cues and praise embedded in Ms. Jones' use of the Inquiry and Science Process Skills models. Ms. Jones used these cues to promote language development in the classroom. But her use of verbal cues was overtly evident in her actions throughout every lesson segment and became a pattern that showed itself more clearly as I progressed through analyzing the data.

SUMMARY

Ms. Jones adopted the role of a cultural translator in the teaching and learning processes. She was knowledgeable, sensitive and comfortable with her language, styles of presentation, community values, traditions and norms. This is a unique style of teaching that leads to academic success (Delpit 1986, 1988), Gee (2004), Ladson-Billings (1994), Lee (1991), and Lemke (1990, 2001, and 2004). This study captured the diverse elements of social, cultural and linguistic aspects of the mediator, with talk being the key medium in classroom interactions.

Ms. Jones was the kind of teacher who possesses practical experience, academic preparation and in-service training. She took appropriate actions in the classroom through her instructional design that created positive academic outcomes for her students as she spoke the vocabulary-rich language of school Science. Ms. Jones used verbal cues, nonverbal cues and praise, and these were important forms of communication in her teaching.

In 90 minutes of videotaped laboratory sessions, there were 44 out of 54 recorded instances of verbal cues being used by Ms. Jones. Of those 54 instances, 43% were open-ended questions, 42% were explanations or elaborations to student responses. In some instances, during her explanations Ms. Jones integrated open-ended and closed-ended questions to enhance the teaching moment.

The next chapter will conclude the study by discussing some of the implications of teaching and learning Science in the elementary grades, and by providing suggestions for further research.

Chapter V: Discussions, Future Research, and Conclusion

INTRODUCTION

In this epoch of education reform, improving instruction is near the top of the list of the many ways to improve student learning. Scores on standardized examinations such as the TAKS (Texas Assessment of Knowledge and Skills) in Texas measure student achievement. But a push for higher test scores, especially for African American/Black, Latino/Hispanic and Native American Indian students, means that schools must overcome obstacles that impede student achievement. In particular, the need to improve learning in the Sciences, technology, engineering, and mathematics (STEM) led me to focus my study on specific aspects of teaching and learning Science in the elementary grades. Specifically, data were generated and gathered around the interactions of one teacher and her students as they completed Science laboratory experiments.

Ms. Jones used the Inquiry and Science Skills Process Models to teach the Science content with the integral vocabulary, language and discourses of Science. Also integral to her instructional design were verbal and non-verbal cues and praise. Ms. Jones' use of verbal cues was significant to her students' development of talk and language and how it was used, written, and constructed.

STRATEGIES FOR TEACHING SCIENCE

The purpose of this research is to determine how Ms. Jones scaffolds students' language development by closely examining the instructional strategies she used to help her students move from "informal Science talk" to "formal Science talk." My primary purpose for designing, implementing and presenting the findings of this study was to illustrate to others the fundamental elements of Ms. Jones' teaching strategies. I wanted to answer answering the following question:

> *How does this teacher scaffold students' transition from "informal Science talk" to "formal Science talk"?*

Ms. Jones' teaching strategies were consciously selected and implemented to meet the needs of diverse learners who, by virtue of their experiential, cultural, and socioeconomic circumstances, challenged orthodox curricula and instructional programs. In this study I hoped to identify and explain Ms. Jones' instructional designs and to explain how and why she chose and adopted them. I was particularly interested in understanding how Ms. Jones adapted her teaching designs to meet the needs of students from diverse cultural, socioeconomic and linguistic backgrounds.

The findings of this study highlight the characteristics of a type of learning environment (a milieu in which teacher and student interactions were a key component) that was organized around a design approach that promoted the use of technical vocabulary. A sociocultural theory based on social, cultural, and linguistic elements provided a lens through which to understand the relationships between teaching and learning in Ms. Jones' milieu (Lemke, 1990 and 2004; Vygotsky, 1978). Figure 5.A shows that the objective of teaching is students learning via Science talk in a milieu where the teacher and students were constantly interacting by instructional design.

Teaching and learning rooted in Science Talk

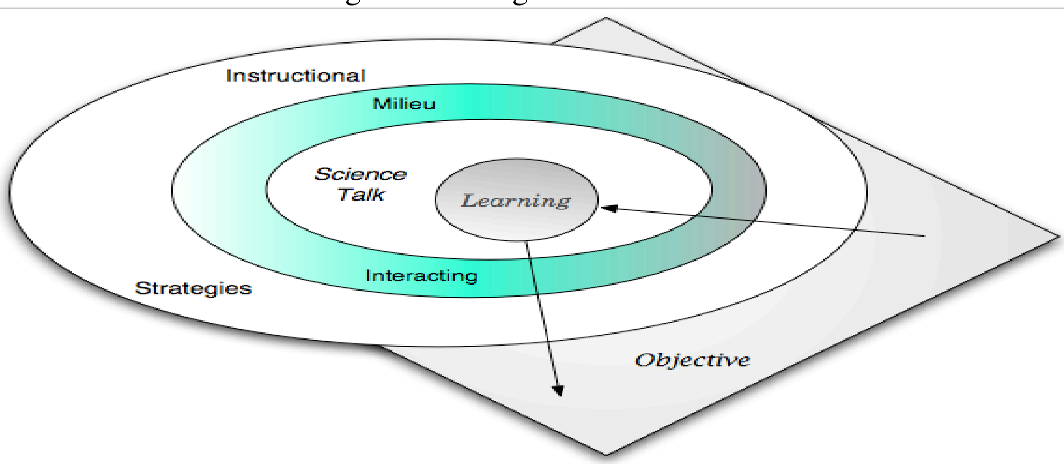


Figure 5.A. The social, cultural, and linguistic elements of teaching and learning interactions that occurred in this co-constructed milieu.

Figure 5.A conceptualizes the context of the classroom social interactions (Vygotsky, 1978) that Ms. Jones developed in these students, providing opportunities for the formation of habits of thinking and doing. Ms. Jones modeled the habits, and her students responded in specific ways and were engaged in thinking about their actions and reflecting about them. Ms. Jones promoted a respect for evidence, a sense of

tentativeness, and a willingness to suspend decisions while exploration proceeded (see lines 42 – 64 below). As Harste writes, "When education is viewed as inquiry, important things happen. The focus of education becomes learning and the task of teaching becomes one of supporting the inquiry process" Harste (1993).

42 S2: We just want to use each beak. We just want to use each beak one time so
43 we can see how it is[8].
44 T: I understand that … if you change a variable … If you have different
45 variables (different beaks) … it is an experiment. You are manipulating that
46 variable.
47 S7: We are not comparing.
48 T: Actually, you are comparing [Also, … because have a different beak …
49 down] and you are collecting … you are not using the same beak. *If she were*
50 *using tweezers, and you were using tweezers, then I would say yeah* … that's
51 a systematic observation.
52 S7: But, we don't have the same one [beak] … we have different ones [beaks]…
53 T: Why not? Why not? I can get tweezers from all the groups. I could not give
54 you all tweezers? Could I not do that?
55 S7: No, …
56 T: Why not? I can get more tweezers. I can go to the store and buy more
57 tweezers. [Ms. Jones was smiling and questioning these students 02, 06, and
58 07 about gathering up all the tweezers, simply getting each of them
59 tweezers.] Do you see what I am saying?
60 S2: We are just trying to see…
61 T: So this is what I need you to do. Rewrite your question so it tells me that you
62 are not comparing. Rewrite your question so it makes sense to others.
63 S7: How will we write it?
64 S6: Like this, how much rice would we pick up if we had our own beak?

Student thinking and actions in this example showed an appreciation of, and regard for, inquiry—and an openness to alternative and competing ideas. The behavior of these three students reflected that they valued and respected themselves and others, and that they took responsibility for themselves as well as others.

With her teaching design aligned with Delpit (2006), Ms. Jones maintained a classroom atmosphere that adhered to academic rigor — she held high expectations for each student, taught critical thinking skills, and developed her students' oral communication skills to debate, explain, evaluate and defend.

[8] Sample Dialogue – Grade 5: An excerpt from the dialogue presented in chapter 4

Verbal Cues via the Inquiry and Science Process Skills Models

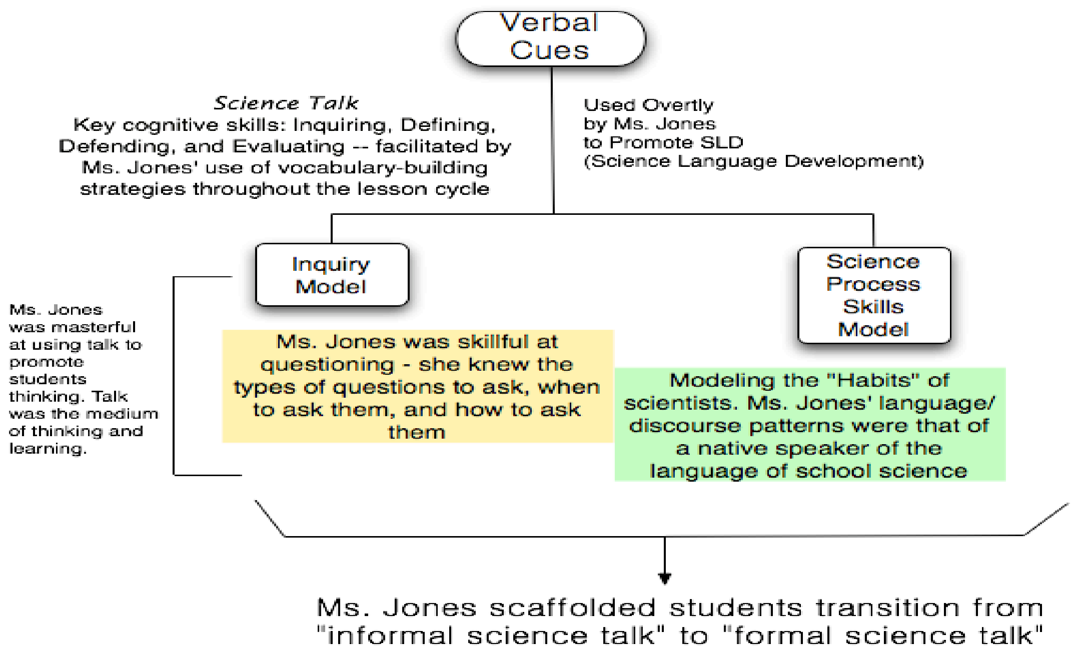


Figure 5.B Verbal Cues --- Scaffolding student's transition from "informal science talk" to "formal science talk"

Table 5.1 provides more details about what other teachers have asserted are effective in classrooms designed around the needs of diverse groups of students:

Table 5.1: Lessons from teachers by Lisa Delpit

- See their brilliance: Do not teach less content to poor, urban children but instead, teach more!
- Ensure that all children gain access to "basic skills" — the conventions and strategies that are essential to success in American society
- Whatever [method] or instructional program is used, demand critical thinking
- Provide the emotional ego strength to challenge racist societal views of the competence and worthiness of the children and their families
- Recognize and build children's strengths
- Use familiar metaphors, analogies, and experiences from the children's world to connect what children already know to school knowledge
- Create a sense of family and caring in the service of academic achievement
- Monitor and assess children's needs and then address them with a wealth of diverse strategies
- Honor and respect the children's home culture
- Foster a sense of children's connection to community—to something greater than themselves

Delpit, L. (2006). "Lessons from Teachers." Journal of Teacher Education, 57 (3), pp. 220-31. The headings for each section of the paper were taken verbatim.

Also, Ms. Jones' scaffolding strategies are aligned with the CRP and discussions of a teacher's conceptions of self and students in Ladson-Billings (1995). Table 5.2 shows Ms. Jones' conceptions of self and students, and her conceptions of knowledge. The tenets of CRP that underlie Ms. Jones' strategies for scaffolding her students' transition from "informal Science talk" to "formal Science" talk are:

Table 5.2: The Tenets of CRP—Ms. Jones

Teacher's conceptions of self and students	*Evidence of Ms. Jones' conceptions of self and students.*	*Teacher's conceptions of knowledge*
1. Teacher sees herself as an artist; teaching is an art. 2. Because the teacher sees herself as part of the community, she can help students make connections between their community, national, and global identities. 3. Teacher believes all students can succeed. [Equity v. Equality] 4. Teacher sees teaching as "pulling knowledge out" – like "mining." [Inquiry Model]	**1.** Due to the dynamic nature of classroom discussions Ms. Jones chose from a variety of scaffolding methods an appropriate method*. **2.** Because of her understanding of the richness of her students' cultures, she allowed them to make scientific associations relevant to their home culture. **3.** Ms. Jones scaffolded the students' transition from long-form, everyday language to short-form, technical Science language because she believed that it was worthwhile; that is, that the students can succeed at learning the language of school science. **4.** Ms. Jones adapted elements of the *Inquiry and Science Process Skills Models* to encourage students to verbalize (make public) what they knew for debate or consensus building.	1. Knowledge is continuously recreated, recycled and shared by teacher and students. It is not static or unchanging. 2. Knowledge is viewed critically. 3. Teacher is passionate about content. [PCK] 4. Teacher helps students develop the necessary skills. [Appropriate use of the technical vocabulary.] 5. Teacher sees excellence as a complex standard that may involve some postulates but takes student diversity and individual differences into account.

Adapted from Ladson-Billings, G., *The Dreamkeepers: Successful Teachers of African American Students* (1995).

[*Ms. Jones chose an appropriate method not the best method. The artful part is that she judged the situation to do this and did not try to apply a doctrine or belief that there was a best method.]

DISCUSSIONS

Instructional Approaches

Broadly stated, the distinct nature of education is dynamic and is shaped by the changing structures of society, culture, and political economy. Academics view education as a deeply social, cultural, political and moral activity. In our complex and changing world, it behooves us to understand the central role of education and the ways in which the theory and practice of education are shaped by this larger context. As O. Lee writes, "As the nation's student population becomes more culturally and linguistically diverse, science educators are increasingly aware of the need to address equity for these students" (O. Lee, 2001, p. 499). Thus, researchers are challenging long-standing and formulaic notions of Science content, learning, teaching and assessment (O. Lee, 2001).

The aim of this study was to use learning theories to explain connections and relationships between a teacher and her students in one Science classroom. Constructivism (social constructivism) one of the central learning theories used for this study. Constructivist ideas can be traced back over centuries, but during the 20th century Piaget, Dewey and Vygotsky, among others, laid the groundwork for its application in an educational context. In addition, over the past two decades the foundation for including cultural considerations as an aspect of learning can be attributed to such researchers as Bruner, Delpit, Gee, Ladson-Billings, Lee, Lemke, and Warren & Rosebery.

Cultural Considerations
Because Equity ≠ Equality

In this study, the cultural aspects of language, especially Science academic language (SAL) included the language of the teacher, instructional materials, standardized examinations and textbooks. SAL includes elements of different "languages" that are spliced together to form a particular "language of school Science." SAL grows from and includes institutional expectations of prior knowledge, background and culture. The vocabulary is technical and domain- and topic-specific. Students from any socioeconomic or cultural background must be fluent in SAL if they are to have any chance to advance in their scientific education. It should be the job of educators to help them acquire these tools. But it is important to add here that at no point should students be expected to surrender any aspect of their home language or cultural attributes.

Educational researchers such as Gloria Ladson-Billings, Lisa Delpit, Jay Lemke, Okhee Lee, and Carol Lee are leaders in developing an educational framework that focuses on designing instructional methods sensitive to language and culture to educate diverse populations of students. One implication for teacher education is that teachers must be trained to see the needs—and the strengths—of diverse student populations, and to use instructional designs that help them to teach these students most effectively. To do this, teachers must know and be able to implement a variety of instructional strategies. They should use instructional designs that are "filled with rhythmic language and rapid intonation with many instances of repetition, call and response, high emotional involvement, creative analogies, figurative language, gestures and body movements, symbolism, aphorisms, and lively and often spontaneous discussions."[9]

Ladson-Billings (1994) defines Culturally Relevant Pedagogy (CRP) as instruction that incorporates teachers' adaptations of subject-matter content to reflect the cultures of their students, and helps students become more aware of, and more knowledgeable about, their own cultures and those of others. This type of instructional approach, Ladson-Billings writes, "empowers learners intellectually, socially, emotionally, and politically by accessing cultural referents to impart knowledge, skills, and attitudes." Ms. Jones, whose teaching is the focus of this study, meets that description.

Technical Science Talk

Lemke's *Science Talk* (1990) provides a framework necessary to develop the grammatical structures and linguistic formations of a new language. But beyond this it is also necessary to create a framework of understanding that emphasizes the role of fluency and competency in Science discourses. (Delpit, 1995; Freire 1970; Gee 1996; Khisty & Chval, 2002; and Noguera 2003). Moore (2007) contends "language acts as a gate to keep out or a bridge that one crosses for access to powerful positions encouraged by language and rules" (p. 320).

The acquisition of "formal Science language" empowers students and provides them with opportunities otherwise lost to them. The route to ascendancy to power requires an arduous climb through treacherous territory, but without fluency in formal

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9 (Culturally Responsive African-American Teachers— http://www.ncrel.org/sdrs/areas/issues/content/cntareas/reading/li4lk11.htm. Retrieved Sunday 14th May 2006.)

Science discourse, the road seems to be guided by a manual that provides only half the information needed to successfully reach the top.

The teaching of Science in elementary schools across the United States should bridge the gap between the students' everyday language and the technical language of Science Talk. We must expect that students can and should learn to be fluent in the technical language of Science Talk. The teacher should not be a gatekeeper, but an interested mediator whose job and personal motivation is to help students successfully do so. To meet those goals, the teacher should engage the students in teacher-to-peer and peer-to-peer dialogues in which understanding of the technical language of Science Talk is gradually built and congealed.

The natural question at this point, then, is this: In teaching students the technical language of Science Talk, in holding them accountable to that set of expectations, isn't the teacher forcing students to succumb to the dominant discourse, which also happens to be associated with male, white, middle-class America? But no gender, class or race owns the language of Science. We should expect hat students who become fluent in Science Talk will take classes in the hard Sciences, and that they will be able to continue on that track in college; we should expect that they will then be able to embark on careers in Science and Technology; we should expect that they will then be able to earn salaries that permit them to provide solid educational opportunities for their own children. Simply providing all students with a superficially "equal" education will not help us to create a truly equitable educational system—or a truly equitable society. My own experiences as a student and as an inner-city teacher of Mathematics and Science have inspired me to find a better way to educate *all* learners. Developing strategies to do so, and providing system-wide professional development for the successful implementation of those strategies, will I hope increase the opportunities for many more students to experience the happy scenario described above. Yes, language can be used to wield power. It can also be used to channel power to useful ends.

FUTURE RESEARCH

Future research on this topic will deepen and broaden our knowledge and understanding of minority educational issues in crucial subject areas such as Mathematics and Science. A great deal of existing research focused on African-American/Black, Hispanic/Latino, and Native American subgroups of the school-age population has shown a tendency for failure, and/or the inability of students in these groups to be schooled beyond the basics. My research interest examines the roles of culture, language/linguistics, and socialization within these communities when learning a specific domain. How can we better understand culture, language/linguistics as barriers to academic achievement? A student's learning capacity is affected by experience, such as how she or he responds to mediation by a more capable or more experienced other. Interactions between people are cultural by nature and social by action; and we all relate to and with each other differently.

Additionally, I would like answer the question, What are the cultural differences each teacher brings to the teaching and learning milieux? In this era of NCLB, I am concerned about the newly established tutoring forces that are being employed by supplementary educational services (SES) providers. The students who qualify to receive these services are from economically and academically disadvantaged backgrounds. What are the qualifications of tutors? How are these tutors being trained to work with students with diverse learning needs?

Closing the "Wound"

Recognizing that five conditions combine to form an undesirable result—namely, the dearth of black students in courses of study for the hard Sciences—I conducted the current study with an eye toward cleaning, disinfecting, dressing and healing the wound. To that end, I first explained that students who are not conversant in the specialized vocabulary that signifies scientific concepts suffer significant disadvantages. "Dumbing down" the language of Science negates the cumulative power to be derived from the conceptual understanding that comes with the technical vocabulary of Science. Accommodationist practices, though expedient in the classroom, have long-term repercussions. These include:

1. "Automaticity" with concept-language connections, the lack of which prohibits higher-ordered thinking of the type required to ascend beyond rote learning (mere knowledge and comprehension);

2. Low acceptance levels to reputable science programs, effectively perpetuating "the wound"—the persistent dearth of black students and black professionals in the hard sciences;
3. No sociolinguistic "ticket" into communities of serious scientists, be they academic, vocational, or professional in nature;
4. Overuse of childish, simplistic, and mnemonic explanation of Science, which effectively kills a student's desire to pursue a course of study that will, of necessity, subject her to many other opportunities for rote learning. Such an approach also robs the student of the *ability* even to truly understand, apply, and manipulate those concepts. In other words, it robs the student of the ability to perform any work of a scientific nature. In that light, "accommodationist" teaching practices visibly perpetuate a form of scientific segregation that divides those equipped for scientific inquiry from those who are not.

To close or heal the "wound," then, we must actively work to empower students from all socioeconomic, cultural and linguistic backgrounds and to encourage them to pursue the study of Science in high school and college-level classes. One of the best ways to do this is to adopt lessons we can learn from the way Ms. Jones taught her elementary-grade students to be conversant in, and comfortable with, the language of School science.

SUMMARY

The purpose of the study was to determine how Ms. Jones scaffolded her students' language development by closely examining the instructional strategies she used. As Moore writes, "Science as a discipline or subject area has its own discourse, both little d and big D, and its own culture of power of Science for moving within scientific arenas. The culture of power of school Science is taught through understanding the language, rules, and discourses of the Science content" (Moore, 2007, p. 321). Therefore, I argued that appropriate instructional strategies at the elementary level are critical to building student's confidence in Science so that they feel empowered to choose Science courses once they are in high school—and beyond.

According to Gee (1999), discourse/Discourse are defined as "language in use" and "ways of acting, interacting, feeling, believing, valuing, together with other people and various sorts of characteristic objects, symbols, tools, and objects in the right places and at the right times so as to…give the material world certain meanings…make certain sorts of meaningful connection in our experience, and privilege certain symbols systems and ways of knowing over others" (p. 13). Ms. Jones' modes of instruction included the use of verbal and non-verbal cues and praise embedded in the Inquiry and Science Process Skills Models. The elements of her instructional design included explaining, elaborating, modeling, conceptualizing, evaluating, exploring, engaging, arguing and defining. Ms. Jones' instructional strategies included the use of verbal and non-verbal cues and praise, which she used to help her students build their vocabularies so that they could move from informal Science into formal Science talk in the language of the domains of Life Science, Earth Science, and Physical Science (See, Figure 5.C).

Medium of Instruction

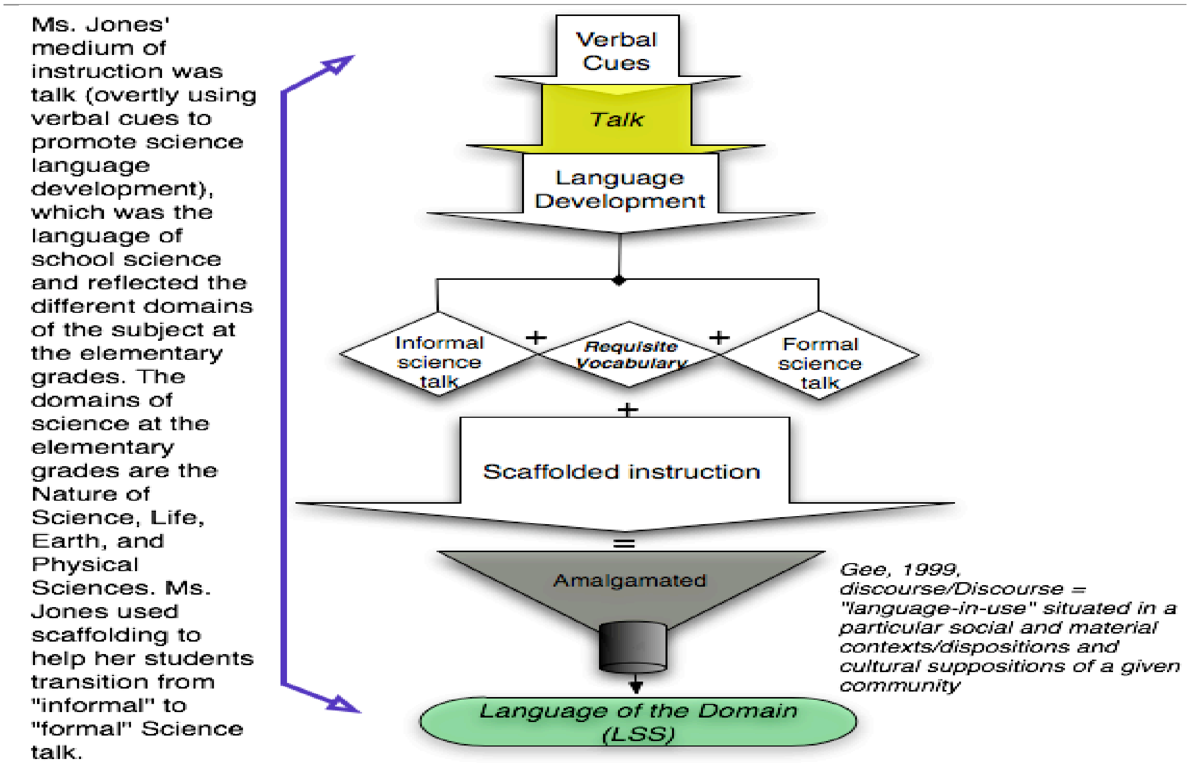

Figure 5.C Ms. Jones medium of instruction: Talk, Science talk through an overt use of verbal cues that promoted Science language development

Ms. Jones' actions provided insight into a classroom that was filled with talk. Interactions between students and students and teacher were very important. Most importantly, Science talk with vocabulary (speaking scientifically), emphasis on students developing complete statements to articulate their thoughts, and development and fluency in use of discourse/Discourse (Gee, 2004) patterns of science by students.

Appendix A

DATA COLLECTION

Spring 2005

Ms. Jones' workload for this semester ranged from 2^{nd} to 5^{th} grade. There were 8 classes not including 5^{th} graders with five teaching periods per day. There were five fifth grade veteran teachers and a fourth grade novice teacher. Observations were conducted with the fourth grade class.

I had an opportunity to spend one week in December 2004 with these students. This was an opportunity for me to get to know them and more so for them to get to know and feel comfortable with me, especially since I will be videotaping their class sessions. During that week the students were working on their science fair projects, which would be held at the school in January 2005. All that week I worked with one group, three boys and one girl. Their science project was about the [real] human heart and how it works compared to an artificial heart. They used play dough to build a diagram of the human heart and a beaker, straws, and colored water for the artificial heart, and they also acquired samples of the artificial heart from the Internet. They use their science textbook for a representation of the human heart. I was one of the judges at the science fair – I did not judge that group. I was a judge for kindergarten and first grades. That group placed second for their project. They said the judges asked tough questions but they knew the answers and even though they were nervous they answered all the questions.

[At the end of each class period Ms. Jones and I sat and talked about 5 to 10 minutes. These discussions were not recorded and no notes were taken. We just talked about what I saw and what was expected for the next day. I noticed that the informal times were relaxing for Ms. Jones. Also, I gave Ms. Jones one of the transcribed interviews to read and she became worried about her grammar. She wanted to change not what she had to say but the grammar. I told her that the information she provided was not being checked for grammar. After that I simply stayed with the informal, no audio- or video-taping or note taking during our after class or interview sessions, which were videotaped and audiotaped respectively. I wanted to work with someone who was comfortable with the entire process.]

*Information on the interactive journals: The usage and the manner in which it is used in from brain research, right side (student reflection) and left side (data collection and notes). [This information was obtained during a one-to-one interview with Ms. Jones]

Spring 2006

All the fifth grade teachers were veterans therefore Ms. Jones went into each class as needed. Observations were conducted in a fifth grade class because the teacher requested help with teaching the *Adaptations* lesson. Ms. Jones stepped in to teach the lesson (all sessions on the topic) as well as serve to model an approach to teaching and learning using the Science Process Skills Model.

Appendix B

TABLE 4.1 : A DESCRIPTION OF TERMS

Term	*Description*
Element (E)	Instances of interactions that were analyzed in detail for the findings in this study
Component (C)	The pieces that made up Ms. Jones' instructional approach
Teacher as Guide (TG)	The teacher has the power and the student is expected to gain power
Teacher as Mediator (TM)	The teacher was the mediator (connector) between the student and what was to be learned
Ongoing Progress Monitoring (OPM)	The ongoing process of collecting and interpreting data for the purpose of improving understanding and adjusting teaching

– Definitions of terms that will be used to describe parts of this study. These terms will aid in providing descriptions of the instances that were selected for analysis.

A SAMPLE POST OBSERVATION INTERVIEW

R: Were there ways in which the lessons were different from what you planned?
Ms. Jones: *The pacing of the lessons always surprises me. I tend to over plan and then have to modify* [OPM] *the time it takes to teach the series of lessons. I have taught this inquiry model several times. I was satisfied with the sequence and strategies used to teach the lesson.*
R: What did the lessons tell you about what your students are learning or still need to learn about adaptation (s)?
Ms. Jones: *At this particular time of the year students should have already had multiple experiences using the* ***scientific process skills****. I was surprised the depth at which I had to teach these skills. It was necessary to provide more scaffolding than planned[TM]. The classroom 10teacher felt the students were successful scientific thinkers. Upon assessing the class, I found that they lack the* ***experience and understanding of process skills such as communicating findings and analysis of data.*** [OPM]
R: How do you plan to further assess students' learning?
Ms. Jones: *I will encourage the classroom teacher to continue to design lessons that develop scientific inquiry* [TG]. *We will use interactive scientific journals to assess students understanding of the processes and content.* <u>*The journals students will include student observations, communications, analysis, models, operational definitions and completed investigations*</u>. ***A four-point rubric will continue to be used to communicate student success.*** [OPM]
R: What challenges have you faced in encouraging students to actively engage in science? Are there challenges to getting the students to apply and discuss the science concepts they have learned? How have you approached these challenges?
Ms. Jones: *Many students are naturally motivated to do hands on science. It is fun and engaging. The challenge comes with those students who are timid or difficult to motivate. They are the ones who struggle with working with others or are afraid to participate for fear of being wrong.* <u>*Modeling is a strategy*</u> *used to help those who are unsure of what to do and what it may look like. Moving around the room, staying in close proximity to groups that seem to be struggling is a strategy that is also effective. Using cooperative group* <u>*instructional strategies*</u> *tends to* ***increase student participation, achievement and social skills acquisition****. Group members serve as peer models. It is important to set students up for* <u>*success*</u> *by providing* <u>*clear expectations*</u> *with regards to* <u>*content and collaborative work.*</u> *Job cards and rubrics are provided to groups so that they are clear about the task at hand and what is expected of each group member. If students understand their role in the group, they will be more likely to participate and feel successful.*
R: What is the next step for this class?

Ms. Jones: ***The bird beak/ adaptations lesson was a model for both the teacher and students*** [TG, TM]. *The classroom teacher was unsure of how to approach scientific inquiry with students. As a coach, I taught the adaptations inquiry lessons in order to increase the teacher's understanding of inquiry and the teaching strategies used to accomplish student success* [TG]. *It will be necessary for **students to experience** other inquiry lessons so that they become **proficient with inquiry**.*

Sample Interview 1: This interview transcript served the purpose, of tying tables 5.2 and 5.3 together, of evidence to teacher actions and researcher interpretations.

This table was adapted from viewing the videotapes to interpret and provide descriptions of Ms. Jones' actions/decision-making strategies. Some of the terms were presented in the chapter 5.

TABLE 4. 2 FROM CHAPTER 4

What Ms. Jones knew and did in the classroom — her classroom strategies were interpreted as:	
Scaffolding	Knowledge of support and guidance a student needed to master a skill. By providing a milieu conducive to learning, the teacher allowed a student to progress from a level of noticeable support, where the teacher modeled strategies to illustrate cognitive processes, to a level where the student has internalized the cognitive processes and could successfully complete a task independently — analogous to ZPD (Vygotsky, 1978).
Mediating	Knowledge of mediation techniques based on the individual needs of each student ---This was interpreted as possessing knowledge and understanding of Vygotsky's Zone of Proximal Development, which was the area between what a learner did independently (mastery level) and what the learning could accomplish with the assistance of a skillful adult or peer (instructional level).
Psychology (Mental Processes)	Knowledge of human behavior and performance, mental processes, and the assessment and intervention for students/struggling students especially those affecting behavior in a given context.
Administration and Management	Knowledge of principles and processes involved in lesson and instructional planning, coordination, and implementation. This included strategic planning, materials rationing out, modeling, mediation techniques, and production methods.
Verbal Proficiency	Knowledge of science that <u>advocated</u> communicating effectively and efficiently in a variety of technical and/or professional languages used within the parameters of teaching and learning.
Content Knowledge	Knowledge of science and was able to make connections and saw relationships between concepts.
Pedagogical Competency	Knowledge of the methods and practices of teaching science, cognizant of the differences in domain requirements and differences in individual student needs. "Pedagogy, the art and science of teaching, is crucial to what students learn."
Designed Instructional Programs	Knowledge of problems faced in science learning, therefore, making connections required an understanding of the problems. *<u>Content</u>:* Science teachers are expected to learn and teach about the process of inquiry *<u>Pedagogy</u>*: Science teachers are expected to plan experiences for their students to make inquires. This presented the intersection in learning how to teach the process of inquiry. Making similar connections relied on a facile understanding of both the content students were learning and how students learned.
Assessed Instructional Need	Knowledge of how people learned in specific domains with flexibility – on-going progress monitoring that led to change in approach.
Education and Training	Knowledge of instructional methods and training techniques included

What Ms. Jones knew and did in the classroom — her classroom strategies were interpreted as:	
	curriculum design principles, learning theory, group and individual teaching techniques, design of individual development plans, and test design principles.
Actively Listened	Listened to what students were saying and asked questions as appropriate, clarified and/or repeated information
Implementation Planning	Developing approaches for implementing an idea: Thinking Creatively -- Originating, inventing, designing, or creating new applications, ideas, relationships, systems, or products.
Coached and Developed Others	Identified developmental needs of others and coached or otherwise helped others to improve their knowledge or skills.
Organized, Planned, and Prioritizing	Developed plans to accomplish work, and prioritized and organized own work.
Updated and Used Job-Relevant Knowledge	Keeping up-to-date technically and knowing one's own job and related job functions.
Learning/Teaching Strategies	Using multiple approaches when teaching or learning new things — Continuously adapts her instructional approaches in ways that fostered the development of the language of science consistent with appropriate scientific vocabulary usage.
Social/Cultural Perceptiveness	Being aware of others' [students or teachers] reactions and understanding why they reacted the way they do.

Table 4.1. Interpretations of Ms. Jones' actions in the classroom — highlighted what she knew and did in the classroom. These were observed actions and teacher descriptions of self in one-to-one interviews

TABLE 4. 6 FROM CHAPTER 4

On-going progress monitoring

	Assessments involved the ongoing process of collecting and interpreting data for the purpose of improving understanding and adjusting teaching. Assessed how well each student was doing during learning.
Assessments	**Formative:** Evaluated information against a set of standards and verified that it was correct: Identified educational needs, developed lessons/laboratory exercises, and taught or instructed. These forms of assessment occurred throughout the learning process. They provided multiple opportunities for students to demonstrate attainment of identified targeted goals without concerns about grading. Formative assessments were varied and accommodated students' abilities to demonstrate knowledge. ***Modes of Assessment:*** Observations**,** Question and Answer sessions**,** Interactive Journal Entries And Group presentations During these processes improvement and/or adjustments were made to teaching or learning. The teacher provided immediate/verbal feedback after assessing individual, group or student, progress up to that point of the teaching and learning process.
↑ *Medial* ↓	This was the time to look backward and forward --- To perform a diagnostic of what students knew and were able to do at this point. This occurred several times during the formative assessment continuum.
	***Summative*:** The nine-week district examination consisted of 25 multiple-choice questions or the 5^{th} grade TAKS examination. The justification for this type of assessment was to make final judgments about student achievement and instructional effectiveness. Throughout the school year, at each nine-week end point the teacher was afforded the opportunity to improve or adjust instructional practice based on the data generated and gathered through the examinations. But, in the case of the TAKS, a high stakes, test this assessment came at the end of the full year learning cycle.

Table 4.6. This table was adapted from Ms. Jones' responses to questions and represents how and why she made informed decisions on her teaching strategies. The dashed lines are used to indicate that the moment of medial assessment is dependent on the student, which the arrows indicate, can move in either direction.

Appendix C: Samples of Vocabulary for Each Data Set

Classroom Observations

Samples from the lessons
Spring 2005 Physical Science - Topic: Density

The vocabulary used for the *density* topic:

Content Obligatory Vocabulary	Content Compatible Vocabulary	
• Matter • Measurement • Distance • Temperature • Time • Mass • Volume • Length	• Matter • Measurement • Distance • Temperature • Time • Properties • Mass	• Density • Volume • Physical Change • Chemical Change • States of Matter

Spring 2006 Life Science - Topic: Adaptations
Animal Adaptations: Bird Beaks (scientists call them bills)

The vocabulary used for the *adaptations* topic:

Content Obligatory Vocabulary	***Content Compatible Vocabulary***	

• Observation
• Materials
• Investigate
• Formulate
• Procedure
• Variable
• Experiment
• Data
• Conclusion
• Explanation
• Graph
	• Observation
	• Materials
	• Investigate
	• Formulate
	• Procedure
	• Variable
	• Experiment
	• Data
	• Conclusion
	• Explanation
	• Graph
	• Systematic observation
	• Prediction (formulate a prediction)
		• Hypothesis (formulate a hypothesis)
		• Manipulated or Independent Variable
		    o What will you change?
		• Responding or Dependent Variable
		    o What will you observe or measure?
		• Controlled or Constant Variable
		    o Which variables will remain the same?

Appendix D: Sample of Analysis of Two Segments

Primary Code	
Q = Questioning (TQ, TQI, SQ) PK= Prior Knowledge TIV = Teacher Introduces the Vocabulary SIV = Student Introduces the Vocabulary T-SI = Teacher-Student Interplay SWJ = Students Writing in Journals	TRR = Teacher Recording Responses TF = Teacher as Facilitator SMP = Students Making Predictions SIG = Students in Groups TESV = Teacher Emphasize Science Vocabulary HOE = Hands-on Explorations
Secondary Code	
VC = Verbal Cue NVC = Non-verbal Cue	G = Gesture P = Praise
Tertiary Code	
COV = Content Obligatory Vocabulary	CCV = Content Compatible Vocabulary

Code	Abbreviation		Code Definitions
Questioning	TQ	VC	Teacher ask(s) question(s)
	TQI		Teacher ask questions: Q&A – an iterative process between teacher and student (s) [This iterative process when conducted effectively, is open and divergent, meaning that Ms. Jones allows for many ways of thinking, interpreting, communicating, presenting, etc.
	SQ		Student ask(s) question(s)
Prior Knowledge	PK TRR SIPK	VC, NVC, G, P	Teacher leads the whole class in a 15 minute discussion about the day's activities --- takes the time to elicit background or prior knowledge about the topic or remind students about prior activities • Teacher records students' responses on chart paper --- this opens up information for discussion, debate, recording, consensus building, etc. • Student initiates and shares prior knowledge through transfer (by looking back at notes or making a mental association)
Teacher Introduces the Vocabulary	TIV	VC	Student uses an everyday term and the teacher aides in the translation by providing the technical term
Student Introduces the Vocabulary	SIV	VC, NVC, G, P	Example: Teacher uses questioning to elicit prior knowledge
Teacher-Student Interplay	T-SI	VC, NVC, G, P	Teacher and students are exchanging ideas, thoughts, helping students in a group settle differences — build consensus, etc.
Students Writing in Journals	SWJ	VC, NVC, G, P	Students are recording: instructions-steps to follow, findings – recoding data, summarizing outcomes,
Teacher Recording Responses	TRR	VC, NVC, G, P	Teacher records students' responses on chart paper --- this opens up information for discussion, debate, recording, consensus building, etc.
Teacher as Facilitator	TM TG		Students are working in groups and Ms. Jones moves from group-to-group asking questions. TM = Teacher as Mediator and TG = Teacher as Guide
Students making predictions	SMP		During whole class and group time Ms. Jones asks questions
Students in Groups	SIG		Students work in groups to work on laboratory assignments: Each member has an assigned duty
Teacher Emphasizes Science Vocabulary	TESV		Teacher says the word for <u>blank</u> is <u>blank</u> or another word for <u>blank</u> is <u>blank</u>.
Hands on Exploration	HOE		This classroom is a laboratory setting where interactions occur in within three contexts: whole class ➔small group ➔ whole class where members of each group present their

Primary Code	
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Secondary Code	
VC = Verbal Cue NVC = Non-verbal Cue	G = Gesture P = Praise
Tertiary Code	
COV = Content Obligatory Vocabulary	CCV = Content Compatible Vocabulary

Code	Abbreviation		Code Definitions
			findings After whole class discussions students move into groups, decide on the role of each member and the materials manager goes to get the needed equipment.
Verbal Cues	VC		Teacher provides words to mediate the student's process: • of arriving at a response (R = response) • student thinking through his/her action (A = action) • of accountable talk (AT) • of a metacognitive action, where he or she questions self (M)
Non-verbal Cues	NVC		Example(s): A nod is a silent sign of assent. Points to charts on the wall to remind students of prior activities.
Gesture	G		Teacher uses her hand to point, signal, or diagram an event or thing
Praise	P		Teacher offers praise for an action --- makes it public to every (She uses the child's action as a "model"
Content Obligatory Vocabulary	COV		COV is a subset of CCV and is defined as word usage that is customary or routine as to be expected of everyone or on every occasion
Content Compatible Vocabulary	CCV		CCV is defined as word usage that is consistent with the domain
Teacher Explains or Elaborates	TE		Teacher provides explanations or elaborates on a students with response sometimes using questions
Teacher Repeats	TR		Teacher repeats student response

	Content-		
Dialogue	Obligatory Vocabulary	Compatible Vocabulary	*Analysis*
1. Teacher: Okay, you want to do capacity… Let's do that on next Monday, then. Yes, yes, I'm. We'll put it in the fridge. Alright, getting started. Boys and girls, let's take a look at our challenge for today. Our challenge is ____. Our challenge today is ____. Who can review? What are we trying to find out and why? Who can help me with the	1. challenge 2. layers mixtures solutions	challenge layers mixtures solutions	***Anticipated Themes*** Verbal Cues = VC Non-verbal Cues = NVC Praise = P Question = Q Teacher introduces the vocabulary = TIV Student introduces the vocabulary = SIV ***Emergent Themes*** Rephrases = R Students uses ***informal*** and

	Content-		
Dialogue	Obligatory Vocabulary	Compatible Vocabulary	Analysis
challenge? Yes, ma'am. ***Student: We are trying to find out if the four mixtures can make layers.*** 2. Teacher: If the four mixtures can make layers . . . [flip page] . . she's using vocabulary that we've used before . . . and so she's using the word mixture. The four mixtures can make layers. Anyone want to comment on that? **Question:** Are they mixtures or are they solutions? Who wants to raise their hand and talk to me? (points to student). Yes, ma'am. ***Student: Solutions*** 3. Teacher: All of the liquids that we are using are transparent. What else. ***Student: Something might be dissolved*** Teacher: Something might be dissolved in them. What is the evidence of that? How do you know something is dissolved in it. (student raises	1. challenge 2. layers mixtures solutions 3. liquids evidence transparent 4. color taste	challenge layers mixtures solutions liquids evidence transparent dissolved color taste	teacher substitutes the vocabulary when rephrasing = S-LF/TSR Teacher asks for clarification = TAC ***Codes*** Overall: PK, TRR, SIPK, VC, NVC, G, P, T-SI, HOE
hand) **[repeats question while pointing at student]**. How do you know there might be sugar or other things dissolved in it? ***Student: They're transparent*** 4. Teacher: Maybe by the color possibly. Maybe, you have you tasted it? ***Student: ooooo*** 5. Teacher: No, we don't want to taste because of safety first. We need to think about lab safety **[points]**. Yes **[giving permission for someone to speak]** ***Student: The thickness…*** 6. Teacher: Maybe the thickness. Like there might be something in it, alright, yes **[points]**. I'm going to interrupt you for a second. I apologize. Another word for thickness, viscosity **[makes face]**. That's a big word **[hand gesture]**. Viscous **[shakes head up and down at students in affirmation]**. Have you heard the word? ***Student: (together) viscous.***	5. safety 6. thickness 7. smell sugar 8. liquids bubbles	safety thickness viscous viscosity smell particle liquids bubbles carbon dioxide	Ms. Jones has created a classroom milieu that is rich in language — the language of school Science (LSS). She believes her students much learn this language because it leads to immediate and future successes academically, socially, and globally. Her approach to teaching advocates for the adaptation of instructional methods and designs that will "stretch" students learning from the immediate interactions to life long learning. In this segment, the teacher

1. COV, Q	2. R, P, COV, CCV, Q	3. Q, COV, VC, SIV	4. Q	5. VC, NVC, G, P, COV
6. COV, CCV, Q, NVC, TIV,	7.	8.	9. Q	10.

Dialogue	Content- Obligatory Vocabulary	Content- Compatible Vocabulary	Analysis
7. Teacher: Absolutely . . . Alright, what were you going to say? ***Student: By the smell*** Teacher: Possibly by the smell. Are there . . . left behind in the cup? There are solid particles in the cup. There is sugar in the bottom of the cup. You actually saw that. ~~You're interrupting~~. Let's do one at a time. ***Student: You could see like some chocolate milk. Once you're finished, you could see like of the chocolate.***	5. safety	safety	students' interactions — the dialogue between teacher and students — espouses for the appropriate use of science vocabulary to explain phenomena. Each class session begins with students entering the laboratory and immediately taking a seat on the floor and Ms. Jones greeting them individually at the door. After the last child has entered Ms. Jones walks into the classroom taking hear seat on a low stool in front of an easel. The class teacher takes a seat at one of the group tables. She takes out a notebook for note taking during the whole class discussion because during group time she too moves from group to group. She elicits prior knowledge through Q&A and waits allowing students time to think about the question and present their thoughts. Sometimes the responses are examples from non-school experiences that they interpret as correlating with the day's activities or the student presents information learned in a previous class session and there are instances where students flip through their interactive journals to find prior learned information. Ms. Jones' offers praise and spells out the child's action to the rest of class indicating a model to follow: use your notes to make connects. Ms. Jones models the appropriate language or introduces the vocabulary based on a student's introduction by informal explanation.
	6. thickness	thickness viscous viscosity	
8. Teacher: Think about our liquids that we were using yesterday, yes. ***Student: That's like, remember in the soda, somehow, little bubbles, rising up are sugar*** ***Student: Carbon dioxide***	7. smell sugar	smell particle	
9. Teacher: He said the bubbles rising up are sugar. ***Students (unison): What?*** ***Student: It's a gas.*** Teacher: It's a gas, how do you know. What's your evidence? They float and what'd you say. They're bubbles. So what's usually in a bubble? A solid or a gas? ***Student: gas***	8. liquids bubbles	liquids bubbles carbon dioxide	
10. Teacher: And they float so that's some evidence that it's probably a gas and not a solid like sugar. What I'm noticing when I'm looking at these liquids is that there are not solid particles in the bottom. So it could be that the solid particles, if there were solids, had already dissolved and in with the liquid, mixed in.	9. gas float	gas float	

	Content-		
Dialogue	Obligatory Vocabulary	Compatible Vocabulary	Analysis
	10. float gas solid liquid evidence mixed	float gas solid liquid evidence particles dissolved mixed	

Segment Two

	Content-		
Dialogue	Obligatory Vocabulary	Compatible Vocabulary	Analysis
1. Teacher: It's a gas, how do you know? What's your evidence? They float and what'd you say. They're bubbles. So what's usually in a bubble? A solid or a gas? ***Student: gas*** Teacher: And they float so that's some evidence that it's probably a gas and not a solid like sugar. What I'm noticing when I'm looking at these liquids is that there are not solid particles in the bottom. So it could be that the solid particles, if there were solids, had already dissolved and in with the liquid, mixed in. 2. ***Student: If there was a solid in the bubble wouldn't it go down?*** Teacher: Say that again (student repeats) Teacher: Would the solid go down? Most solids go where? ***Student: to the bottom*** 3. Teacher: To the bottom. What does that tell you about density? ***Student: It's heavier. To the***	1. gas* evidence* float bubbles solid* sugar liquids bottom mixed 2. solid bubble solids bottom 3. heavier float	gas* evidence* float bubbles solid* sugar liquids bottom particles dissolved mixed solid bubble solids bottom density heavier float	*Codes* 1. Q Q Q Q 2. SQ Q Q 3. TR Q SQ SQ 4. P, P, TIV, TIV, TIV, COV, CCV 5. 6. 7. SIV TIV * indicates the word was used more than once in that episode Student asks a question: ***What about things that float on top of water?***

	Content-		
Dialogue	Obligatory Vocabulary	Compatible Vocabulary	Analysis
bottom. Maybe it's heavier. It might be heavier. Yeah, that's another thing, what about things that float on top of water? ***Student: what?*** 4. Teacher: I don't know. There's another word that we're going to talk about this week. It might have to do with capacity. It might have to do with . . . It might have to do with mass. It might have to do with something else and we'll talk about. And we'll talk about buoyancy. Let's go back to . . . Let's go back . . . I love your comments . . .challenge . . . Our challenge is about a solution so the liquids we are using today are solutions. Are solutions and what is our challenge? Yes, ma'am. (student raises hand, ooo, ooo). What's our challenge? I like how you are using your notes. ***Student:*** Teacher: When you . . . liquids without mixing . . and we're trying to discover what? Which one is more dense? Possibly layering this liquid. We use our observation skills to discover which one is denser or ____ Yes, sir ***Student: When our table . . . we first . . um, after, when we put in . . . it went down, but it didn't*** ***Student: The green was more dense than the . . . the green went down***	4. capacity mass solutions liquids mixing discover more dense layering liquid observation denser	capacity mass solutions liquids mixing discover more dense layering liquid observation denser buoyancy	

	Content-		
Dialogue	Obligatory Vocabulary	Compatible Vocabulary	*Analysis*
5. Teacher: Did you hear what he said? Put the green in first. Tell me if I'm wrong. They put red in first. Then they put green on top of it. Then the green went down and the red. ***Student: Then they mixed (hand gesture).*** Teacher: It criss-crossed each other. Yes, sir ***Student: Is*** Teacher: It will make layers . . . to make a new color. What do you think? The question is "Is it made of something?" It is a different liquid . . . different materials in it . . . pigment or colors ***Student:***	5. color layers materials	color layers materials pigment	
6. Teacher: We have to test the density again, that's a different liquid. We're looking at again, today, so the question is . . . why do you think that happened? Red go first. Yes, red went first, but then green all of a sudden went down below. Is that evidence of anything? Green is more what? Evidence that it is denser. ***Student:*** Teacher: What other liquids did we put together that did not combine? ***Student:***	6. liquid liquids	density liquid liquids	
7. Teacher: So do all liquids mix together and combine? ***Student: Oil is like a magnet, when put at opposite sides, won't go.*** Teacher: . . . . Magnets. . . are you thinking about the word "repel". It's almost like that, alright. So we have some evidence about density with those two liquids so we want to find out . . . which one is the most dense? Which one is the least dense? Which ones are kind of in the middle and can we get them into layers? So what is your strategy? To get them into the straw? What? What did you do with your partners to discover which ones are most dense or least dense? What are some strategies or some processes that. . . How are we going to do this?	7. liquids mix combine oil magnet opposite magnets repel evidence liquids	magnets repel density liquids more dense most dense least dense	

Raw Data: The two segments above were extracted from this transcript.

Student:
Teacher: You did or did not. Do you wanna look in the room real quick for it?
Student:
Teacher: Will you look in the room for it? Look around.
Student:
Teacher: Oh, you know what . . . Look over there (points).
Teacher: I wanna do writing first, then coloring, and the gluing last.
Teacher: I'm wired (class laughs) . . . Is that close enough? (class laughs again).
Student: So she can hear you talk
Teacher: She's recording (laughing kids)
Teacher:
Teacher: Testing . . . hello . . . hello . . . alright! Let's just pretend that this is not on me. Let's just pretend that the video camera is not in here. We know it, um. . . . She's doing a study and . . . She's studying you and she's studying me and she's doing that for her class. We're going to ignore the camera and do not wave at the camera (counting off with her fingers). We're going to stay focused . . . To be perfectly honest, I need you focused. I need you focused on our task. Like we normally do everyday. Behave like you normally do everyday. You have great questions and you have comments and great thinking skills so that's what we're working on. You have a question before
Student: She has a class. Is she going to show her class?
Teacher: She's not going to show her class. She's going to view the video. She's going to use what she sees on the video to write a report. So for me sometimes I forget what happens . . . or what I see . . . I won't be able to write about it. Some people have great memories. You guys have really great memories. I don't have a great memory, um, and sometimes. And sometimes you have to look for very specific details. She's looking for very specific details of how we talk with each other. How we talk with each other. How I talk with you.
Student: Are we going to ___?
Teacher: Alright, last question about this, then we're moving to science, go
Student: When can we bring the Coke?
Teacher: I don't understand the questions. Start again.
Student: You said we could bring a Coke or something.
Teacher: Okay, you want to do capacity . . . Let's
Student: If there was a solid in the bubble wouldn't it go down?
Teacher: Say that again (student repeats)
Teacher: Would the solid go down? Most solids go where?
Student: to the bottom
Teacher: To the bottom. What does that tell you about density?
Student: It's heavier. To the bottom. Maybe it's heavier. It might be heavier. Yeah, that's another thing, what about things that float on top of water.
Student: what?
Teacher: I don't know. There's another word that we're going to talk about this week. It might have to do with capacity. It might have to do with . . . It might have to do with mass. It might have to do with something else and we'll talk about. And we'll talk about buoyancy. Let's go back to . . . Let's go back . . . I love your comments . . .challenge . . . Our challenge is about a solution so the liquids we are using today are solutions. Are solutions and what is our challenge? Yes, ma'am. (student raises hand, ooo, ooo). What's our challenge? I like how you are using your notes.
Student:
Teacher: When you . . . liquids without mixing . . and we're trying to discover what? Which one is more dense? Possibly layering this liquid. We use our observation skills to discover which one is denser or ____ Yes, sir
Student: When our table . . . we first . . um, after, when we put in . . . it went down, but it didn't
Student: The green was more dense than the . . . the green went down
Teacher: Did you hear what he said? Put the green in first. Tell me if I'm wrong. They put red in first. Then they put green on top of it. Then the green went down and the red.
Student: Then they mixed (hand gesture).
Teacher: It criss-crossed each other. Yes, sir
Student: Is
Teacher: It will make layers . . . to make a new color. What do you think? The question is "Is it made of something?" It is a different liquid . . . different materials in it . . . pigment or colors
Student:
Teacher: We have to test the density again, that's a different liquid. We're looking at again, today, so the question is . . . why do you think that happened? Red go first. Yes, red went first, but then green

do that on next Monday, then.
Yes, yes, I'm. We'll put it in the fridge.
Alright, getting started. Boys and girls, let's take a look at our challenge today. Our challenge is ____. Our challenge today is ____. Who can review? What are we trying to find out and why? Who can help me with the challenge? Yes, ma'am.
Student: We are trying to find out if the four mixtures can make layers.
Teacher: If the four mixtures can make layers . . . flip page . . she's using vocabulary that we've used before . . . and so she's using the word mixture. The four mixtures can make layers. Anyone want to comment on that. Question: are they mixtures or are they solutions? Who wants to raise their hand and talk to me? (points to student). Yes, ma'am.
Student: solutions
Teacher: All of the liquids that we are using are transparent. What else?

Student: Something might be dissolved
Teacher: Something might be dissolved in them. What is the evidence of that? How do you know something is dissolved in it. (student raises hand) (repeats question while pointing at student). How do you know there might be sugar or other things dissolved in it?
Student: They're transparent.
Teacher: Maybe by the color possibly. Maybe have you tasted it.
Student: ooooo
Teacher: No, we don't want to taste because of safety first. We need to think about lab safety (points). Yes.
Student: The thickness
Teacher: Maybe the thickness. Like there might be something in it, alright, yes (points). I'm going to interrupt you for a second. I apologize. Another word for thickness, viscosity [makes face]. That's a big word (hand gesture). Viscous [shakes head up and down at students in affirmation]. Have you heard the word?
Student: (together) viscous.
Teacher: Absolutely . . . Alright, what were you going to say?
Student: by the smell
Teacher: Possibly by the smell. Are there . . . left behind in the cup? There are solid particles in the cup. There is sugar in the bottom of the cup. You actually saw that. You're interrupting. Let's do one at a time.
Student: You could see like some chocolate milk.

all of a sudden went down below. Is that evidence of anything? Green is more what? Evidence that it is denser.
Student:
Teacher: What other liquids did we put together that did not combine?
Student:
Teacher: So do all liquids mix together and combine?
Student: Oil is like a magnet, when put at opposite sides, won't go.
Teacher: . . . . Magnets. . . are you thinking about the word "repel". It's almost like that, alright. So we have some evidence about density with those two liquids so we want to find out . . . which one is the most dense? Which one is the least dense? Which ones are kind of in the middle and can we get them into layers? So what is your strategy? To get them into the straw? What? What did you do with your partners to discover which ones are most dense or least dense? What are some strategies or some processes that . . . How are we going to do this?
Student: . . . Doing the same thing?
Teacher: Like, what do you mean, doing the same thing? You're going to do the steps.
Student:
Teacher: like what?
Student: . . . gonna make some combinations
Teacher: See
Make combinations of
I don't
What do you mean?
What am I
Do you want to try, sir.
What
Where am I gonna put it? Use your notes to help you. I have one friend over here, Danielle, is going to help. Look at your notes everybody. Notes are here. What are we gonna do first? How are we going to do this? Everyone's looking at their notes. Everyone's looking at their notes for procedures. Notes on the chart, that's why they're there. Alright. What do you think we should do first? What do the steps tell us?
Student: Insert . . . insert
Teacher: Insert a what?
Student:
Teacher: A potato . . . at an angle. What angle? Okay, so we all know that the potato's there for a reason. To hold the straw up. What do we do next? Sir
Student: liquids
Teacher: Make some decisions. Now that you know a little information about liquids. S3 and his partner were already

Once you're finished, you could see like some of the chocolate. Teacher: Think about our liquids that we were using yesterday, yes. Student: That's like, remember in the soda, somehow, little bubbles, rising up are sugar Student: carbon dioxide Teacher: He said the bubbles rising up are sugar. Students (unison): What? Student: It's a gas. Teacher: It's a gas, how do you know? What's your evidence? They float and what'd you say. They're bubbles. So what's usually in a bubble? A solid or a gas? Student: gas Teacher: And they float so that's some evidences that it's probably a gas and not a solid like sugar. What I'm noticing when I'm looking at these liquids is that there are not solid particles in the bottom. So it could be that the solid particles, if there were solids, had already dissolved and in with the liquid, mixed in.	discovering . . . about what order you're going to put your liquid, then what do we do third? S17, what are we gonna do next? Student: (no answer) [phone rings] Teacher: Keep reading Student: Teacher: I'm sorry, so add the next three liquids. So try to discover the uh . . . what's it say. Absolutely, try to discover the different combinations of . . . why use this piece of paper. Student: To show how many different ways to get it Teacher: Different combinations. If it did layer. If the liquids did layer, what are we gonna do? How? Data. If the liquids did not. If they actually started to blend and mix together. How are you going to show this? Yes sir. Student: Probably, like . . . color of it . . . the ones that are mixed. Teacher: Alright! I noticed here. That she actually colored in, the red and the green. Mixed together. Can we make a note off to the side? Sentence, what happened to this combination? We could . . . don't forget to tell me what combination you added. And you can use the initials, you don't have to write yellow all the way .. and then keep notes, if they did or did not layer, does that make sense?

Appendix E

BLOOM'S TAXONOMY IN MS. JONES' MILIEU

Ms. Jones used a variety of instructional techniques (which included verbal and nonverbal cues, gestures, hands on experiments, video and written media, pictorials, graphs, etc.) that have been identified to accommodate individual preferences in learning. This table, E-1, of information utilizing Blooms' Taxonomy to describe the types of questions and responses that were observed in the classroom.

Background

The contexts of this study were two primary school, 4th and 5th grades, classrooms being taught by a science teacher specialist (Ms. Patricia Jones) who served in dual roles as teacher of students and teachers. Elementary science covers broadly the areas of the nature of science, life, earth, and physical sciences.

Bloom's Taxonomy of Learning

The taxonomy covers the level of abstraction of questions that are prevalent in educational settings through written texts, teacher language, and standardized examinations. The cognitive domain involves knowledge and the development of intellectual skills. In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behavior important in learning. For five decades now, these classification levels have been integrated into the goals of the educational processes

Level of Cognition	Bespoken Aptitude	Samples from the classroom
Knowledge	*Question Cues:* list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.	Question: *What happened after you changed the amount of time [variable] you needed to get your food? What happened after you changed the shape [variable] of the clay?* Demonstrated: For example, students know how to change a variable to get a different outcome?
Comprehension	*Question Cues:* summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend	Question: *Can you provide an example of what you mean...?* Demonstrated: For example, students can explain in their own words the steps for performing a task (systematic observation or experiment.
Application	*Questions Cues:* apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover	Question: *What factors would you change if...?* Demonstrated: For example, students modified their team question to reflect whether they will conduct an experiment or a systematic observation for their laboratory exercise.
Analysis	*Question Cues:* analyze,	Question: *Can you compare your ... with*

Level of Cognition	Bespoken Aptitude	Samples from the classroom
	separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer	*that presented in...?* Demonstrated: Example, students gathered information about a ball of clay, clay boat and used that information to determine whether the object sank or floated.
Synthesis	*Question Cues:* combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if? compose, formulate, prepare, generalize, rewrite	Question: *Can you write a new question your group would like to investigate?* Demonstrated: For example, students integrated information from different sources to develop a new question. Also, students revised their group question to get the desired outcome based on whether they will conduct a systematic observation or an experiment.
Evaluation	*Question Cues*: assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize	Question: *What changes to the question would you recommend?* Demonstrated: For example, students debated with the teacher and other class members (outside of their immediate group) to decide on developing their group question. They also, explained and justified the need for a new group question or keeping the one already developed.

From Benjamin S. Bloom *Taxonomy of educational objectives*. Published by Allyn and Bacon, Boston, MA.

http://www.coun.uvic.ca/learn/program/hndouts/bloom.html

TABLE 4. 5 FROM CHAPTER 4

Language Development and Learning

Cognitive Process	*Level of Acquisition*	*Inquiry Process*	*Language Process*	*Vocabulary Process*
Knowledge *&* *Comprehension*	*Surface* *(Concrete operational)*	Exploration permits students to get acquainted with a problem or phenomenon and decide what type of experiment to set up.	*Text Meaning* *(Literal and affective)*	Student use everyday words integrated with little or no technical vocabulary.
Application *&* *Analysis*		Through experimentation and data collection, students carry out experiments, take measurements or make observations, and report on data they have gathered.		Student use everyday words but integrate some/more technical vocabulary.
Synthesis *&* *Evaluation*	*Deeper* *(Formal operational to Abstract and Formal)*	Sense-making allows teacher and students to discuss the usefulness of the data, interpret the data, and develop explanations and concepts.	*Institutional Meaning* *(Interpretive and abstract)*	Student integrates the technical terms with ease and frequency.

Table 4.5. Adapted from English as a Second Language (ESL) research on student-mediated processes of language development and learning. The terms concrete and formal operational, abstract and formal are Piagetian by usage.

MORE DETAILED SAMPLES OF QUESTIONS: THESE ARE EXAMPLES OF ADDITIONAL QUESTIONS MS. JONES USED IN THE CLASSROOM

1. Students are studying the great mathematician Archimedes. While taking a bathe Archimedes discovered that the water level went up when he stepped into the water. He also learned the relationship between floating and sinking items and their densities, which helped him, identify a real crown from a fake one using his bathtub.

   Students decided to conduct a buoyancy experiment using a ball, a cup and a tub of water. They placed the ball and cup in the water and observed that the ball sank to the bottom and the cup floated on top of the water. Give a reasonable explanation for this result. How could this information help a scuba diver?

2. Students are exploring buoyancy by placing solids and liquids in water to see if they sink or float. They find that water can support many objects in the classroom. They discover, through reading, that water can hold up large animals such as whales. Describe an experiment using the following materials that will illustrate buoyancy.
   - Aluminum

- 20 pennies
- Tape
- Plastic container of water
- Paper and pencil

3. Students are studying properties of matter. They want to learn as much as they can about the properties of a wooden cube and a rubber eraser. They record physical properties of each object on the chart. They place the wooden cube on a balance to find its mass. They also mass the rubber eraser. To get the volume they immerse the wooden cube in a beaker filled with 50 ml of water. They repeat the process with the rubber eraser. Below are the results of their measurements. Determine the correct volume for each object. Then explain how comparing the mass with the volume of the object can be used to determine which object has the greater density. Is there a way to determine which object has greater density without calculating the mass and volume? Explain.

4. Students are studying solutions. They add several 5 ml spoonfuls of salt to 50 ml of water. Each time the salt is added they observe the water level go up. Describe a way to collect information about how much the water level will change each time an amount of salt is added.

5. Students read articles in the newspaper and medical journals about scientists who study the impact of fast food on the human body. The articles say that many people are becoming overweight and unhealthy because of the fat and sugars in the food that they eat. How will this research affect people? Describe a solution to those people who would like to improve their health.[E-1]

[E-1] I selected this question because it presented implications and relevance to real life and/or some cultural health issues many people in society face.

Appendix F: Line-by-line Data Analysis and Interpretation

Purpose of Disquisition: The purpose of the study is to determine how a teacher scaffolds students' language development by closely examining the instructional strategies used. I argue that appropriate instructional strategies at the elementary level are critical to building student's confidence in Science such that they feel empowered to choose Science courses once they are in high school. This empowerment is developed through "talk" that teachers and students are engaged in at the elementary level. The focus of the study was how one teacher scaffolded the language of school Science (LSS) development with technical vocabulary as an integral part of that process. She helped her students transition from "informal science talk" to "formal science talk."

Selected segment: This segment of the selected dialogue was the beginning of the session. Ms. Jones began this laboratory session by providing students with directions. Students were guided through the steps on how to begin writing up their work line-by-line.

> T: You are going to write it on the line. List your manipulated variables on the first line. List your responding variables on the second line. And, list all your control variables on the third line. Are there questions? … Begin, You have two minutes.

A sample dialogue:

This is a 90-line dialogue segment from the videotapes (Data Set 2) that was transcribed verbatim. The codes developed and used were:

Verbal Cues (VC) – TGT (Teacher gives a time limit), TPIC (Teacher provided information for clarification, TPD (Teacher provides directions), TPI (Teacher Provides Information), TQ (Teacher Questions), TTCQ (Teacher Tries to get Clarification Through Questioning), TUV (Teacher Uses the Vocabulary), TR (Teacher Rephrases)
Subset VC: SQ (Students Questions), SC (Student Clarifies), SUV (Student Uses the Vocabulary), PS (Power Shift from Teacher to Student), TSRQ (Teacher and Students Rephrase Question), TNS (Teacher Nomination of Student)

Non-Verbal Cues (NVC) – TSH (Teacher Shaking Head), TUH (Teacher Using Hands), TLS (Teacher Looking at Student)

Praise (P) – TOP (Teacher Offers Praise) – This includes calling on a specific student to give her/his thoughts and turning to entire class opening the way for any student to get involved.

According to Lemke (1990), the teacher and students play a dialogue game through an organizational pattern, which provides the structure within which they talk Science. There is an activity structure of questions, bids and nominations, answers and evaluations. The sample dialogue segment was coded below to provide descriptions.

	Cues			Vocabulary		Question		
Line	V	NV	P	COV	CCV	S	T	Codes
0	☑				Manipulated variables			TPI, TC, TQ, TGT, TUV
1	☑			responding	Responding, Responding variables			
2	☑			control	Control, Control variables		☑	
3	☑			control	Control, Control variables			
4	☑			responding	Responding, Manipulated variables, Responding variables			
5		☑						
6		☑						
7								
8		☑		different, beaks	Different, Beaks	☑		SQ
9		☑					☑	TQ, TTCQ
10	☑			different, beaks, rice	Different, Beaks, Rice			SUV
11	☑			different	Different		☑	TQ, TTCQ, TUV, TR
12	☑			different	Different		☑	
13		☑				☑		SC
14		☑					☑	TTCQ, TUV
15	☑			tweezers	Tweezers, Habitat		☑	SUV
16	☑			tweezers	Tweezers		☑	TTCQ, TUV
17		☑					☑	
18		☑						SD
19		☑						TPD, TPIC
20	☑			tweezers	Tweezers, Habitat		☑	
21	☑			tweezers	Tweezers			SUV, SC
22		☑					☑	
23	☑			comparing	Comparing			SC

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	Cues			Vocabulary		Question			
Line	V	NV	P	COV	CCV	S	T	Codes	Brief Descriptions
24	☑			beak, different	Beak, Different				
25		☑						TPD, TPIC, TPD, TPI,	
26		☑							
27		☑				☑		TSRQ	
28	☑			beak	Beak	☑			
29	☑			beak	Beak		☑		
30		☑					☑	TQ, TTCQ	
31		☑					☑		
32		☑							
33	☑			beak	Beak		☑		
34		☑							
35	☑			beak	Beak		☑		
36		☑							
37		☑							
38	☑			beak	Beak		☑		
39		☑							
40		☑							
41		☑							
42	☑			beak	Beak				
43		☑							
44	☑			variable, different, variables	Variable, Different, Variables				
45	☑			different, beak, experiment, variable	Different, Beak, Experiment, Manipulating, Variable				
46	☑			comparing	Comparing				
47	☑			comparing	Comparing				
48	☑			Collecting, beak, tweezers	Collecting, Beak, Tweezers				
49	☑			tweezers	Tweezers, Systematic				

Brief Descriptions:

Vocabulary:

Systematic Observations
- Measure
- Over time
- Not comparing

Prediction
I think … because …

Experiment
- Compare

Hypothesis
If … then I think …
Tell what the difference will be …

Habitat: sandy beach, swamp, prairie (grassy), log
Environment
Food: corn, rice, nuts, worms
Beaks: tweezers, tongs, pliers

Ms. Jones questioned members of the group individually as well as collectively
She was trying to make sense for herself while trying to get these students to clarify the group question for themselves as well as others with whom they will communicate/debate their study and findings

	Cues			Vocabulary		Question			
Line	V	NV	P	COV	CCV	S	T	Codes	Brief Descriptions
50	☑			observation	Observation				Key terms: Appropriation Internalization [Vygotsky]
51		☑		beak, different	Beak, Different				
52	☑			tweezers	Tweezers		☑		
53	☑			tweezers	Tweezers		☑		
54		☑							Open call for any student to participate
55	☑			tweezers	Tweezers		☑		There is a shift in power, Ms. Jones invites everyone to get involved in helping the group to rephrase their question (they must decide on a group question)
56		☑							
57		☑					☑		
58		☑					☑		Rephrasing the question will help these students to better determine their course of action --- systematic observation or experiment
59		☑							
60		☑							
61		☑							
62		☑				☑			Line 88 – TNS: Teacher Nomination of Student, Ms. Jones called on a student by name to give his/her thoughts about the situation the group was face [See the rest of the conversation below]
63	☑			beak	Beak	☑			
64	☑			beak	Beak		☑		
65	☑			wrench	Wrench				
66	☑			wrench	Wrench		☑		
67							☑		
68	☑			rice, beaks	Rice, Beaks				
69	☑			comparing	Comparing				
70			☑						
71								PS , TOP	
72	☑			dilemma, problem					
73		☑							
74		☑							
75	☑							PS, TOP	
76	☑							PS, TOP	
77						☑			

	Cues			Vocabulary		Question			
Line	*V*	*NV*	*P*	*COV*	*CCV*	*S*	*T*	*Codes*	*Brief Descriptions*
78	☑			beak	Beak				
79	☑			wrench	Wrench				
80		☑							
81		☑							
82	☑			tweezers	Tweezers				
83		☑							
84	☑			tongue depressor, different, beak	Tongue depressor, Different, Beak				
85	☑			different, beak	Different, Beak				
86		☑							
87	☑			observation, experiment	Systematic observation, Experiment				
88		☑	☑				☑	TNS	
89		☑	☑					PS	

This table was adapted from Lemke, J. (1990). Talking Science. Abex Publishing Corporation. Stake, R. E. (1995). The art of case study research. Sage Publications. COV is a subset of CCV and I am coding COV and CCV paralleling Gee's (2004) definitions of "discourse" and "Discourse."

What was happening after this segment of the selected dialogue ended?

I am providing the reader with the dialogue as it continued:

> S3: I think it's a systematic observation because they never said anything about comparing to each others beak. An experiment will be like getting … say like how much food each of them must get and they compare it like on a graph or something like that.
> [Ms. Jones is in the background saying … mmm, … mmm]
> T: Read your question again. Tell me what words in their question makes you think that. Read the question one more time
> S6: How much rice would we pick up if we had our own beak?
> T: You changed the word from "different" to "own?" Right?
> Here is what they first said. Read it the first way.
> S6: How much rice would we pick up if we had different beaks?
> T: If we had different beaks? That's the way they said it the first time. What do you guys think about the way they wrote it the first time? Does it sound like they are comparing?
> S0: I don't
> T: You don't! Why?
> S0: Different doesn't mean comparing.
> S2: Now it sounds like comparing. Different just means something else … it's not the same.
> T: I have another group that says – How much food can we collect out of different habitats? They used the word different. And, they said they were comparing habitats.
> S6: They have an experiment.
> S2: That's because of the way they put the question
> T: Oh! If the way you write the question makes it sound like it an experiment. Can you change the way you write the question to make it a systematic observation.
> S2: [Shakes head up and down]

Appendix G: Sample Artifacts

G-1
Who sank the Boat?
By Pamela Allen

Beside the sea, on Mr. Peffer's place, there lived a cow, a donkey, a sheep, a pig, and a tiny little mouse.
They were good friends, and one warm sunny morning, for no particular reason, they decided to go for a row in the bay.

Do you know who sank the boat? [Ms. Jones asked students to make predictions. Students made their predictions.]

Was it the cow who almost fell in, when she tilted the boat and made such a din?
No, it wasn't the cow who almost fell in.

Do you know who sank the boat? [Students were given the opportunity to keep their original prediction or change based on the new information. The new information was that the cow did not sink the boat.]

Was it the donkey who balanced her weight? Who yelled, 'I'll get in at the bow before it's too late.'
No, it wasn't the donkey who balanced her weight.

Do you know who sank the boat? [Again, students were given the opportunity to keep their original prediction or change based on the new information. The new information was that neither the cow nor the donkey sank the boat.]

Was it the pig, as fat as butter, who stepped in at the side and caused a great flutter?
No, it wasn't the pig as fat as butter.

Do you know who sank the boat? [At this point the conversation changed to talking about the tiny mouse.]

Was it the sheep who knew where to sit to level the boat so that she could knit?
No, it wasn't the sheep who knew where to sit.

Do you know who sank the boat?

Was it the little mouse, the last to get in, who was lightest of all?
Could it be him?

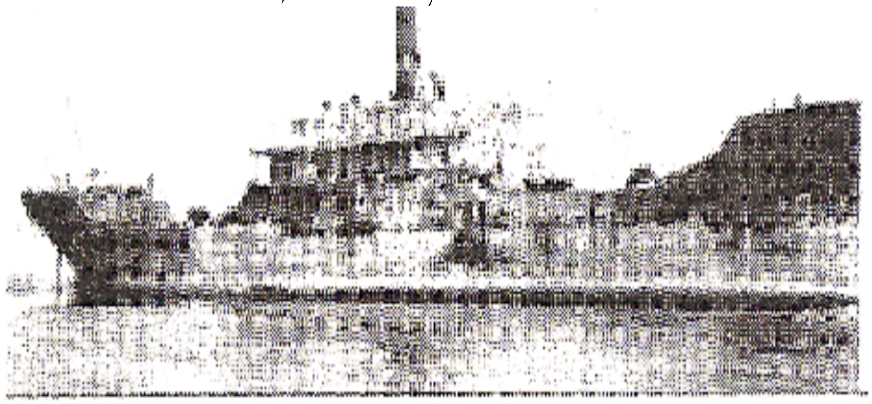
You DO know who sank the boat.

[At our debrief that day Ms. Jones talked about her surprise at how much the students enjoyed the book. Especially, since it was a first grade book. The students were excited about making their predictions and changing them based on new information. Also, they started thinking about the weight of each animal.]

G - 2

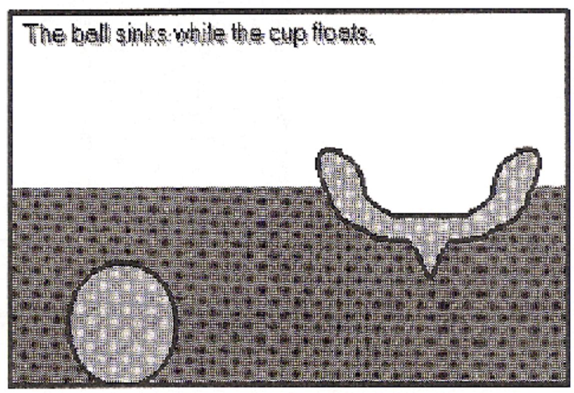
Experiment with Buoyancy

How does a ship float? Well, some ships are made of wood, and wood floats, so in that case is easy to understand. What about ships made of heavy steel, though? Or the concrete ships (above) that were constructed during a steel shortage at the end of WWI? Steel and concrete are heavier than water, how do they float?



A ship will float as long as it weighs less than the water it pushes out of the way, or displaces. Ships can use materials in their hulls that are heavier than water, but there must be air within the ship. Since the air doesn't weigh as much as the water, this lowers the weight of the ship compared to the same volume of water, this lowers the weight of the ship compared to the same volume of water. Try this experiment to see how trapping air in a ship can make it float. You will need a lump of clay and a sink filled with water.

Step 1- Roll the clay into a ball and place it in the sink. Does it float? It shouldn't because the clay weighs more than the water.

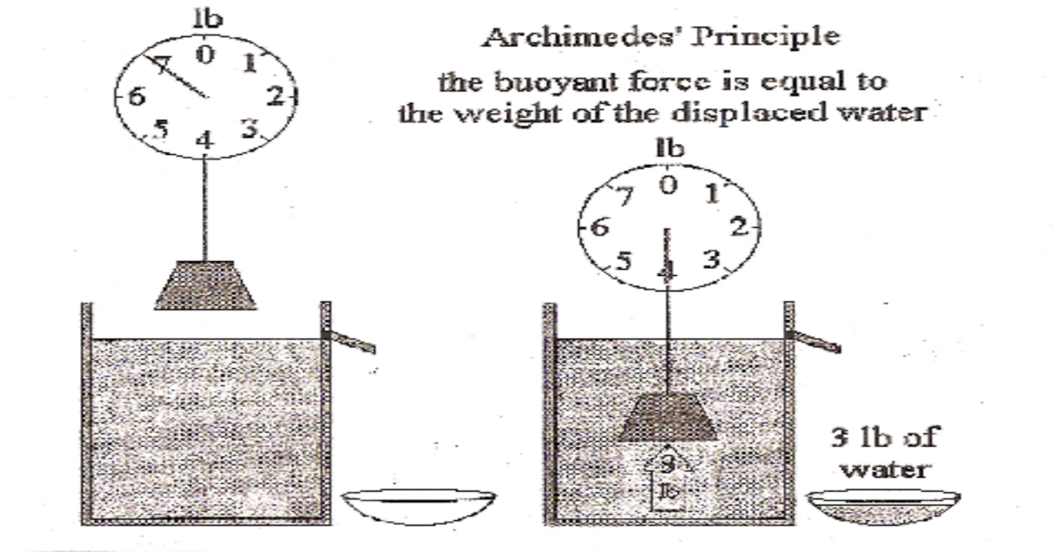


Step 2 – Now shape the clay into a rounded cup and put a small lump on the bottom as a keel. Put it in the water with the open part of the cup facing up so it stays filled with air. Does it sink? It shouldn't. As long as the bowl of [] cup is large enough and contains air the clay will float. This is because the air makes the clay ship weigh less than the water it displaces.

Step 3- Now fill the bowl of the cup with water. Does it sink? It should. When the bowl is filled with water the clay ship weighs more than the water it displaces and sinks.

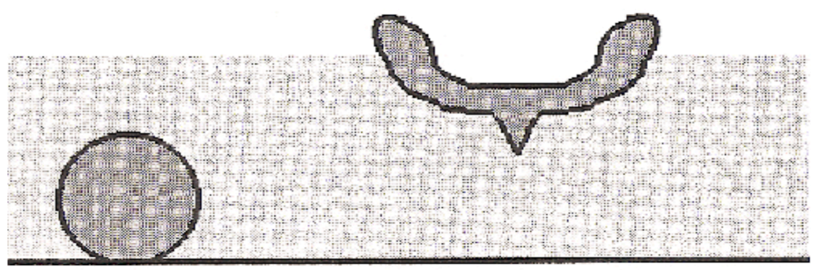
When a ship floats it is said to have positive buoyancy. When it sinks it has negative buoyancy.

Archimedes' Principle



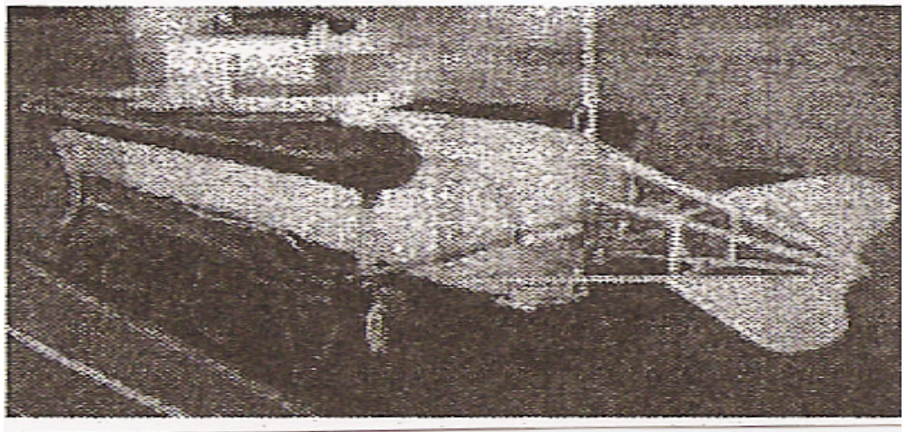
- If the weight of the water displaced is less than the weight of the object, the object will sink.
- Otherwise the object will float, with the weight of the water displaced equal to the weight of the object.

Archimedes' Principle explains why steel ships float
Ball: displaced water weights less than ball
Hull: displaced water weight = hull weight



G-3

Build a Pen Cap Submarine



Submarines go up or down based on their buoyancy. That is when they weigh less than the water they displace they go up. When they weigh more they go down. If they weigh exactly the same they float right where they are.

Submarines vary their weight by adjusting the amount of air in the ballast tanks. You can use a pen cap and a bit of modeling clay to build a submarine that goes up or down as the amount of air in it's ballast tank shrinks and enlarges.

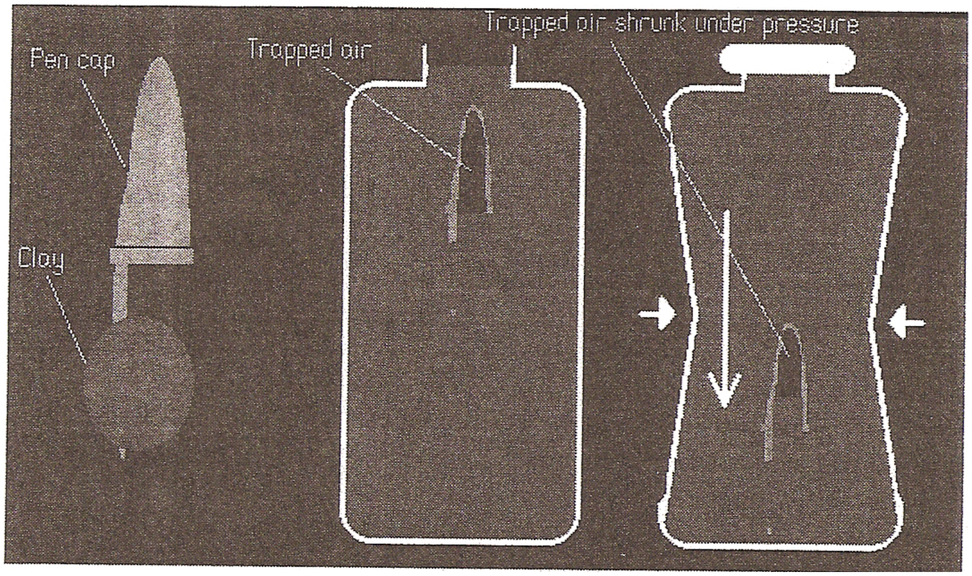
Step 1: You need a pen cap, modeling clay, a plastic bottle with a mouth large enough to get your "submarine" through and the bottle cap. (The cap must close air tight on the bottle so that when you squeeze the bottle water won't come out the top).

Step 2: Make your submarine by putting a ball of clay on the stem of the pen cap (See diagram, below). The opening to the hollow portion of the pen cap should be facing down. The hollow portion is your sub's ballast tank.

Step 3: Put the "submarine" in water (clay down so the air is trapped in the hollow portion of the cap) and then add or subtract clay until the "submarine" floats just below the surface of the water. It now has neutral buoyancy.

Step 4: Fill the bottle with water and put the "submarine" into it. The sub should float just below the neck of the bottle. If it falls to the bottom or floats on the surface adjust the amount of clay.

Step 5: Make sure the bottle is full and put the bottle cap on tightly
Step 6: Squeeze the bottle. This will cause the pressure inside to go up and any gas trapped inside the bottle (like the air inside the pen cap) will shrink. This will change the buoyancy on your "submarine" from the neutral to negative and it will sink to the bottom. When you release the pressure the air will expand and the sub will rise.



My Notes

There was a whole class open discussion. Then specific students were called upon. This led to a discussion about open and closed systems.

- Not everyone had a model
- Students were shaking their submarines for a cause and effect
- They talked about bubbles (air) and water in the cap causing the cap to sink or float©

G - 4
Science Fair
Judging Questions, Vocabulary, and Judging Rubrics

Below are some possible questions you may ask students.

- What did you want to find out…? Why?
- What did you think would happen?
- Tell me about your project. (Can the student explain project clearly?)
- Explain how this works.
- Why did it work that way?
- Does that remind you of anything else? (Asking students to compare)
- Tell me how you organized your data.
- How does the graph or chart tell about what happened? (Can the students interpret data using a graph or chart)?
- Were you surprised by the results? Why or why not?
- How did you find information for your project?
- Did anyone help you? Who? How did they help?
- What could you do next to find out more about…?
- What new question(s) do you have about…?

Oral and Written Vocabulary

Title	Results	Exhibit	Classification Scheme
Problem	Conclusion	Model	Accurate Spelling
Hypothesis	Definitions	Demonstration	Label
Background Information	References	Report	Clear and Relevant
Materials	Acknowledgement	Rubric	Clear and Concise
Procedure	Elaborate	Written Information	Informative
Experimental Procedure	Diagram/Picture	Explanation of the Exhibit	Similarities and Differences

This table was adapted from the handout given to judges at the Science Fair. This table is by no means exhaustive of the vocabulary I encountered in writing, heard, or overheard at this Science Fair.

Experiment Rubric

An experiment is a test of a question. Begin by asking questions about why something might be true or what would happen if… What you think might be the answer is called your "hypothesis." Then design an experiment or test, which will help you find the answer to your question.

	1	*2*	*3*	*4*	*5*
Title	No title or irrelevant Incorrect spelling Not neat Illegible Not labeled	Incorrect spelling not neat or illegible, Relevant Not labeled	Legible Relevant Correct spelling Informative Labeled	Neatly labeled Clear Informative and relevant Correct spelling Interesting	Catchy or attention grabbing including a graphic Neat/typed Clear/concise Accurate spelling Informative
Problem	No problem statement or a statement that is: misspelled Not neat Illegible Not in the form of a question Irrelevant Not labeled	In the form of a question but is: incorrectly spelled Not neat or illegible Not labeled	In the form of a question that is testable Relevant Labeled Correct spelling Legible	In the form of an open ended question; not just a yes or no question Testable Correct spelling Neat Labeled	An exceptional open ended question Testable Labeled clearly Neat/typed Correct spelling
Definitions	No definitions or misspelled Not neat Illegible Students unable to use words in context or demonstrates misunderstanding of words.	Definitions are not displayed Neat/typed Labeled clearly Correct spelling	Definitions are displayed Neat/types Labeled clearly Correct spelling Student understands meaning of words.	Student defines operationally. Definitions are displayed student has no trouble using words in context of an explanation. Labeled clearly Neat/typed Correct spelling	Student defines operationally. Student can use all words in the context of an explanation and can elaborate and apply meaning to new idea. Labeled clearly Neat/typed Correct spelling
Hypothesis	No hypothesis or irrelevant Incorrect spelling Not neat Illegible Not labeled	Student predicts what the result will be, however doesn't tell why. Incorrect spelling Not neat Not labeled	Students predicts what the result will be and tells what they think "I think…because" Testable Legible/neat Correct spelling	Is stated in an If…then testable statement (what you will do…what you will see) Labeled clearly Neat/typed Correct spelling	Student tells the relationship between the manipulative variable and the responsive variable. Labeled correctly Neat/typed Correct spelling
Background Information	No background or plagiarized No references Not clear Messy/misspelled Not labeled	Background in students own words but contains errors in: content, Spelling and clarity No references Not labeled	Students describes the topic an includes: at least on reference Clear Labeled Correct spelling Neat	Student describes the topic: 2 references Clear Supports topic Neat Correct spelling and labeled	Student describes the topic and includes: At least 3 resources including at least one Internet resource Clear/concise Supports topic Neat/typed Correct spelling and labeled

An experiment is a test of a question. Begin by asking questions about why something might be true or what would happen if… What you think might be the answer is called your "hypothesis." Then design an experiment or test, which will help you find the answer to your question.

	1	2	3	4	5
Experimental Procedure	No procedures listed or not in students own words Not labeled Misspelled Not clear	Procedures included but include incomplete or unclear steps. Incorrect spelling Not labeled Not neat or illegible	Student describes the steps taken to complete the investigation. Clear-repeatable Correct spelling Labeled	Student describes the steps taken including the mention of variables. Clear and repeatable correct spelling typed and labeled	Student describes in detail the steps taken including independent, dependent, and controlled variables. Clear/repeatable Typed and correct spelling
Results	No results listed or displayed or results irrelevant to question. Not clear or neat Misspelled Not labeled	Results listed but not clear or incomplete. Incorrect spelling Not labeled Not neat or illegible	Student describes what happened. Uses tables and/or graphs to display data. Neat/clear Correct spelling Labeled	Student describes the results clearly using tables, graphs, etc. demonstrates how data was recorded in detail, quantifying information. Neat	Student describes results in detail and demonstrates obvious systematic collection of observations and measurements. Displays tables, graphs, pictures, and log. Accurate/clear/typed
Conclusion	No conclusions or conclusion is irrelevant to question. Not clear or neat Misspelled Not labeled	Students attempts to use data, however conclusion is not clear or incomplete Misspelled Not labeled	Students answers the question posed. Evident that student read the data (graph, table, etc) and interpreted information accurately. Clear, neat, labeled	Student explains the information presented and uses it to answer questions. Student is able to note patterns in data. Clear, concise, neat	Student answers question and include predictions by interpolating and extrapolating patterns based on resulting data. Clear/concise Neat/typed
References	No references or acknowledgments listed	References and/or acknowledgements listed. Not in correct format. Not labeled Not neat or clear Misspelled	At least one reference and acknowledgement is included. Written in correct format. Clear/neat Spelled correctly	At 2 references or acknowledgements listed. Written in correct format. Clear and neat Correct spelling	At least 3 references and acknowledgements listed. Written in correct format. Clear, neat, typed Correct spelling

Exhibit: Model, Demonstration, or Display with Report Rubric

	1	2	3	4	5
Title	No title included or irrelevant Incorrectly spelled Not neat or illegible Not labeled	Included but incorrectly spelled or not neat/illegible not labeled but relevant	Legible relevant and informative correctly spelled neatly written or typed	Relevant, clear and informative interesting neat/typed correctly spelled includes graphics	Catchy or attention grabbing neatly displayed with graphics Clear and relevant accurate spelling informative
Written Information	No information included or is inaccurate or irrelevant. Not neat or illegible not labeled.	Information is included but does not state clearly the purpose of the exhibit Not neat or illegible not label relevant	Written information is included exhibit description of an idea, object or event. Description includes purpose, diagrams, or pictures. Neat and clear.	Written information is included describing the model. Included is the comparison to reality by noting similarities and differences. Clear/neat.	Written information is in report form. Elaborates and makes comparisons. Shows detailed diagrams or pictures that are labeled. Clear, neat, typed.
Explanation of the Exhibit	No explanation or is irrelevant. No model is exhibited. Not neat or illegible. Not labeled.	Explanation and model is included but is: not clear, not neat, not labeled	Student describes what the exhibit shows. (How does it work?) Includes diagrams, model or pictures that are labeled. Explanation is clear.	Student is able to describe how object, event, or idea works. Diagram, picture or model is clearly labeled. Student can elaborate.	Student is able to elaborate and can apply to another idea or object or event. Explanation is detailed clear, neat, typed. Includes diagrams, etc.
Results & Conclusion	No results or conclusion included or is irrelevant. Not neat or illegible. Not labeled or incorrect format.	Student includes results or conclusion but does not state clearly what was learned. Not neat or illegible.	Student is able to describe what was learned. Written in report format and answers the question or purpose of the exhibit. Clear, neat.	Result describes what the student learned. Includes detailed description of diagrams, pictures or model. Student can elaborate.	Student is able to report on what was learned with great detail and elaboration and can apply to new ideas. Clear, neat, typed.
References & Acknowledge-ments	No references or acknowledgements listed.	References and/or acknowledgement s included, however not incorrect format, not labeled, neat or clear. Misspelled.	Includes at least one reference and/or acknowledgement. Written in correct format. Clear, neat, spelled correctly.	Includes at least 2 references. Written in correct format. Clear, neat, typed, and spelled correctly.	Includes at least 3 references. Written in correct format. Clear, neat, typed, and spelled correctly.

Collection with Classification Rubric

	1	2	3	4	5
Title	No title included or irrelevant Incorrectly spelled not neat or illegible not labeled	Included but incorrectly spelled or not neat/illegible relevant not labeled	Legible, relevant, correctly spelled, informative, neatly written or typed	Included and neat/typed clear and informative relevant correctly spelled interesting	Catchy or attention getting, neatly displayed, typed, clear/concise, accurate spelling, informative
Information	No information about the in the classification is included or is inaccurate or not	Information is included but is: not neat or illegible, not labeled, relevant	Student includes information about the collection. Information is in students' own	Student includes detailed and accurate information about the collection.	Student includes information in the format of a report about the object(s) in collection.

	1	2	3	4	5
	relevant plagiarized not neat or illegible not labeled		words. Clear, neat, accurate, labeled	Information is clearly written and displayed neatly and labeled. Student where the collection was found. Neat, typed, labeled.	Information is comprehensive and clear. Neat/typed/labeled.
Classification	No classification indicated. No evidence or explanation of groupings. No labeling Not neat or illegible	Student attempts to sort and classify by similarities and differences. Some errors are evident, relevant, not labeled, not neat or illegible	Student includes representation or physical groupings based on similarities and differences. Objects are sorted and labeled accurately. Near, clear.	Student includes verbal and written explanation of sorting. Similarities and differences are evident. Clearly labeled accurate. Neat/typed	Student groups objects according to similarities and/or differences. Student includes subsets and is able to explain and elaborate on groupings. Accurately labeled Neat, typed
References	No references or acknowledgements listed.	References and/or acknowledgements listed, however not in correct format, not labeled, neat or clear. Misspelled.	At least one reference and/or acknowledgement is included. Written in correct format. Clear/neat spelled correctly.	At least 2 references or acknowledgements listed. Written in correct format. Clear, neat, typed Spelled correctly	At least 3 references and/or acknowledgements listed. Written in correct format. Clear, neat, typed Spelled correctly.

Appendix H: Additional Feedback from Ms. Jones

Data Sheet

Science Teacher Specialist

H - 1

1. What will be today's instructional approach? **Student-centered instruction** where students take an active role in their own learning. They ask inquiry questions, problem-solve and perform investigations. The teacher acts as **facilitator**. **My approach is to provide opportunities for students to reason scientifically and answer their own questions or guided questions.**

Additional Questions:

1.1. Describe the role of the facilitator (active and/or passive). How do you determine which role is appropriate at the time? **I want to place the responsibility for learning in the hands of the students. I try to start with what they know and build on that knowledge with new experiences in order to produce a lasting understanding of content knowledge and skills. As a facilitator I try to provide meaningful experiences, many of which are guided experiments. As an "active" facilitator I ask guiding questions, provide some instruction – all the while wanting the students to think, talk, and problem solve. I try to be a "guide on the side" type of teacher. I have long since relinquished the idea of "knowing it all." Often times I learn alongside the students. As a "passive facilitator" I tend to step back and listen to students. I want to hear what they have to say to each other. Often time the collaborative conversations and group work provides enough support/scaffolding for students to grasp the scientific concepts and processes.**

1.2. Would you consider yourself a mediator? Why or why not? **I do step in to mediate certain situations, however, I would rather students mediate situations or problems themselves.**

2. What factors did you consider when making your instructional choice(s)?
   - Cooperative grouping and roles for group members
   - Access to instructional materials
   - Data collection and **clear communication**

Additional Questions:

2.1 Are there any student factors? What are they and explain the part they play in your decision-making? **I try to take into consideration each individual student. Factors include learning styles, time students' need on task, modifications for particular student, girls/boys passive students v. "active" students, etc. I try to provide experiences where all students play a role. All students have a job. I try to set clear expectations for all students so that they know what they are**

responsible for.

2.2 How do you define clear communication? **Being able to communicate student learning at first in student's own terms and then with scientific terms.**

H - 2

How is your **Philosophy of Teaching** incorporated into the **"Modeling"** and **Professional Development** you provide for teachers?

In our last discussion regarding my philosophy, I stated that I believed "all students can learn." I believe it is our responsibility to see to it all students move forward in their learning. To do this I try to incorporate the components of "best practice" in science (Not in any [particular] order):

1. Questioning (Open ended – probing)
2. Wait time
3. Debriefing – discussion – use analogies – etc.
4. Reading in science
5. Hands-on (Inquiry Based) --- Challenging/ Rigor
6. Graphic organizers/concept mapping/visuals
7. Journaling/Writing in science
8. Model thinking/discussion
9. Homework
10. Problem solving
11. Ongoing, embedded authentic assessment
12. Relate to real life
13. Metacognition

By incorporating best practice strategies I hope to recognize and address the learning needs of all students. I try to use an abundance of hands-on inquiry based activities as well as other strategies in order to help students develop a broad and realistic understanding of science concepts and processes. I want students to gain confidence in their abilities as scientists. I also want this same confidence when it comes to teachers. Many teachers have come to me and stated their lack of confidence with regards to their science background knowledge and their science teaching. I hope to provide a quality model, either through professional development (workshops) or model teaching.

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Vita

La Vergne Lestermeringolo Thatch was born September 9, 1967 in Georgetown, Guyana. She moved to the United States in 1980, and after graduating from Samuel J. Tilden High School, New York City, in 1985, she attended Pratt Institute and received a Bachelor's degree in Mechanical Engineering from that school in 1991. From 1993 to 1998 La Vergne taught middle school life/earth sciences and mathematics, and coordinated the science fairs, at a public school in Brooklyn, New York City. In 1998 she received a Master's degree in Mechanical Engineering from the City College of New York. She taught high school mathematics in Brooklyn from 1998 to 1999. From 1999 to 2001, she taught high school mathematics and zoology in Queens, New York; she also served as the school's dean of discipline. In 2000, she received a Specialist Diploma in School Administration and Supervision from Queens College in New York City. From 2001 to 2005, during her time at The University of Texas at Austin, La Vergne worked as a graduate research assistant and program assistant as part of the technology team developing and distributing the Online Teacher Reading Academies (K—4). Currently, Mrs. Lestermeringolo Thatch is the owner, founder, and director of The Education STREaM, Inc., a research, development and consulting firm she has created based on her many years of experience in education. STREaM Academy is a learning center that provides one-to-one tutoring in the areas of science, technology, reading, engineering and mathematics. Mrs. Lestermeringolo Thatch has been married for four years and has one child, Elizabeth.Kristine noeLL Thatch.

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